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# MOVEMENTS OF WATERFOWL BROODS IN MANITOBA

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# PREFACE

"Movements of Waterfowl Broods in Manitoba" is the result of a cooperative program of the University of Minnesota, the Delta Waterfowl Research Station of the Wildlife Management Institute, and the Fish and Wildlife Service.

The University of Minnesota initiated the study as a thesis problem for Charles Evans; the Delta Station furnished funds, facilities, and assistance for the exploratory work during the first summer; subsequently the Fish and Wildlife Service named Charles Evans a collaborator and financed the project. Coauthors William H. Marshall and Arthur S. Hawkins gave general guidance to the investigation.

Of the many complex problems in waterfowl management, few need more attention than those concerning the relations between the birds and their breeding environment. Studies like the one reported here should bring about better management through better understanding of the birds and what they need to maintain themselves.

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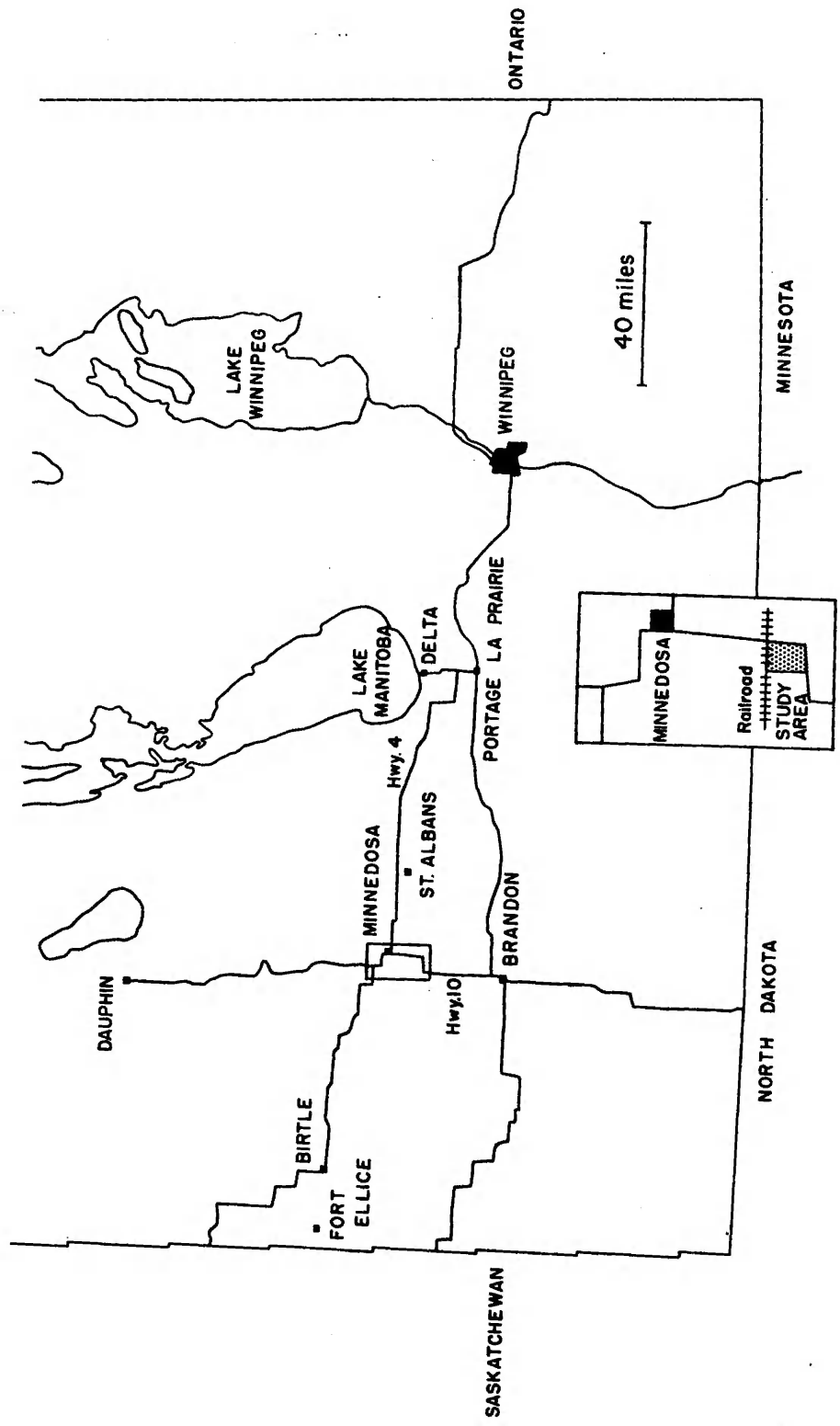
PLATE I

# LOCATION OF AREAS MENTIONED IN TEXT



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# I. INTRODUCTION

Since there has been a lack of information concerning the habits and requirements of waterfowl broods and the factors influencing their welfare, a study was undertaken in an attempt to shed some light on the following questions:

1. Brood movements. The primary objective was the determination of the extent to which broods move from one water area to another, the distances they are able to travel, and the factors which initiate the movement. Leopold (1933) states that "the mobility of a species determines the minimum unit of management." To manage most efficiently small water areas as waterfowl breeding grounds, we must know something of the mobility of the broods.

It has been known for some time that broods do travel overland. Bennett (1936) mentions a mallard nest 2 miles from the nearest water. Hochbaum (1944) cites several instances of the travel of broods overland at Delta, Manitoba. In some cases they were deserting shrinking sloughs to move into the permanent waters of the main marsh. Ducks Unlimited, in its work to improve waterfowl breeding grounds, has constructed a number of "kee" waters described by Russenholt (1942) and Farrington (1945). Five to eight "kee" waters per township are created by draining small water areas into large ones and establishing permanent lakes. This procedure is based on the assumption that broods hatched in temporary or "phantom" waters, which later dry up, will then be able to travel overland for distances of 2 to 3 miles to reach these permanent areas.

2. Brood preferences as to water areas. A secondary objective was to obtain quantitative data on the ecological and physical characteristics of areas used by broods.

Previous studies of brood preferences are as follows: Bennett (1938) found that 30 percent of the blue-winged teal in northern Iowa marshes used a mixture of bulrushes (Scirpus spp.) as rearing cover. Furniss (1935) in a study of 99 small areas in Saskatchewan found that the size of the area was an important factor influencing use by broods and concluded that half-acre areas were the most productive. Bennett (1938) obtained similar results in northern Iowa. Low (1940) found that redhead brood in Iowa favored bulrushes as rearing cover.

3. Brood mortality and dispersion. As a result of intensive field work on the above points, considerable information was obtained on mortality and dispersal. Some work on this phase of the life cycle has already been done by means of brood counts (Bennett, 1938; Low, 1945; Williams and Marshall, 1938).

4. Preferences of breeding adults. Some data were obtained on the use of different types of potholes by breeding adults. This phase of the annual cycle is of importance in determining breeding distribution and density.

5. The evaluation of the productivity of an area in terms of young produced by a known number of breeding adults. Analysis of data obtained allows for an interpretation of the production of a pothole area. This is one objective of the waterfowl-breeding-ground survey of the U. S. Fish and Wildlife Service (Williams 1948a, 1948b, 1949, 1951). Bennett (1938) was able to estimate the production of an area in Iowa by combining data on nesting success and on mortality of the young to arrive at the total number

of young produced. Low (1945) found that the production of redheads on breeding areas in Iowa was 398 flying juveniles for 100 nests. Stoudt (1938) was able to estimate the number of waterfowl produced on the Chippewa National Forest of Minnesota by means of careful brood counts.

6. Classification of water areas. Since an understanding of preferences of young and adults is partly dependent on the observer's ability to arrange water areas in groups with common characteristics, a system must be devised for classifying them. The classification used and developed in the present study is based on the physical characteristics of the water areas as they relate to waterfowl use and to plant succession. Those areas are grouped together which have common features judged to be important from this standpoint.

## II. THE STUDY AREA

### General Description

Location -- The first of two summers devoted to this project, the summer of 1948, was spent at the Delta Waterfowl Research Station at Delta, Manitoba, working on a technique for marking young birds for identification and observing the habits of broods (Evans, 1951). The summer of 1949, June 12 to September 3, was spent near Minnedosa, Manitoba, 80 miles west of Delta, where the field work described in this report was carried out.

Geology -- This area is over 1,600 feet above sea level and is overlain with a thick layer of glacial till derived from the granites of the Laurentian shield and limestone from the district of lakes Manitoba and Winnepeg, mixed with shale from the nearby underlying strata (Ellis, 1938). The surface is somewhat rolling; uplands are usually well drained. Depressions are filled with water from melting snow and from rains and form water areas varying from small temporary puddles to ponds of 10 acres or more. The soils of the region are northern black earths which are predominantly clay loams formed under tall-grass prairie followed by aspen groves.

Climate -- The average annual precipitation for the period from 1885-1894 as given by Bird (1930) for the aspen parkland varied from 18.80 inches at Winnipeg to 17.38 at Fort Ellice and 17.14 at St. Albans. The distribution at Fort Ellice was as follows: winter (December, January, February), 2.41 inches; spring, 3.65 inches; summer, 8.30 inches; and fall, 3.02 inches. The greatest amount fell in June.

Currie (1948) describes the vegetative season as the period in which the mean daily temperature is at least 42° F. and the minimum at least 32° F. For the region of Minnedosa, this period begins the second half of April and ends the first half of October.

During 1949 water levels were generally high. A partial record from the Minnedosa weather station shows that the precipitation was 15.30 inches for the vegetative season. Two rainstorms which greatly affected the area during the study occurred on July 20 (1.34 inches) and July 28 (2.93 inches). These replenished the surface waters after a relatively dry June and early July.

Land Use -- The study area included about 976 acres or 1½ square miles, of which about 560 acres (57 percent) were under cultivation, producing mainly wheat and barley, with some oats, and 140 acres (14 percent) were used as permanent pasture. In 1949, augmented by spring and fall grazing of cultivated areas, the pastures supported 36 cattle and 11 horses. During

the spring (after break-up about the end of April until planting time in early June) and again in the fall (from harvest time, about the end of August, until freeze-up some time in November), the gates to the pastures were opened and the stock were allowed to wander over the cultivated areas to make use of the forage in the field borders and fence rows and on the margins of water areas.

About 160 acres (17 percent) were not under intensive use and consisted mainly of fence rows, road allowance, unpastured aspen groves, and grassy field borders. This area included about 10 acres of dry meadow cut for hay, and roughly 20 acres of margins of water areas from which marsh hay was taken. About 25 acres were newly cultivated land, broken in 1949 (a practice becoming prevalent in the region as the second generation has begun farming the land, creating a higher demand on its productivity).

The remaining 116 acres (12 percent) consisted of water or wet areas.

Upland Cover -- The vegetation of the region varied considerably owing to the influence of slope on soil moisture and temperature, and to the effects of land use in the form of small-grain cultivation and grazing.

The following description depends to a large extent on information from Bird (1930) who made a study of the biotic communities in the aspen parkland at Birtle, about 80 miles west of Minnedosa. The description has been modified to some extent to conform to conditions as found at Minnedosa.

Woody growth was mainly aspen (Populus tremuloides), with some burr oak (Quercus macrocarpa) on drier sites. These aspen groves were generally surrounded on dry sites by a shrub zone in which snowberry (Symphoricarpos racemosus) was the most common plant, while chokecherry (Prunus virginiana), saskatoon (Amalanchier sp.), and hawthorn (Crataegus sp.) also occurred. Between the aspen and the emergent vegetation on wet sites, there was either a border of wet meadow consisting of grasses and sedges or a zone of willows (Salix spp.). Bird states that the willow zone is present around the wet areas where there is no concentration of alkaline salts, but where such salts are present the succession is directly from marsh to prairie, consisting primarily of wheatgrass (Agropyron richardsonii), junegrass (Koeleria cristata), bentgrass (Agrostis hyemalis), and needlegrass (Stipa comata).

Basis of Classification -- Lowland cover, which had a more direct influence on waterfowl, was studied in greater detail by the author.

## Water Areas

The water-filled depressions already mentioned have come to be known by waterfowl biologists as potholes, and will be referred to as such in this report, even though the term is generally used by geologists in an entirely different connection.

There were 127 potholes on the study area, which were separated into 10 classes. These were in four major groups according to permanency, as shown in Table 1. The two groups which contained emergent aquatic vegetation were further classified according to the character of that vegetation. The extent of the vegetational survey which served as a partial basis for classification is indicated by Table 2, which shows the number of areas that were cover mapped, the number which had water gauges placed in them, and the area, depths, and drop in water levels of those potholes for which these data were known.

Water Levels -- Owing to the late date and the lack of time, water gauges were not set up at the beginning of the study. Heavy rains at the end of July apparently filled the potholes to capacity and provided a standard by which the relative rates of water loss could be read. Forty-four gauges were established within 2 days of the storm. These were willow sticks driven firmly into the bottom soil and notched at the water surface to provide a reference point. The relative rates of fall in water levels of the various types as measured during the period from July 30 to August 21 are shown in Table 2.

Area -- Areas of the potholes as reported in Table 2 were calculated by means of a field application of the weight method described by Welch (1948). The outlines of the potholes were transferred from aerial photos (scale: 3" = 1 mile) to a map at a scale of 48" = 1 mile. The outlines were checked in the field to make sure they corresponded to the borders of the potholes as indicated by the transition of the vegetation from moist-soil to upland species. This transition line was judged to be more stable than an estimate of the high-water mark. Frequent checks of the size of the outlines were made by pacing.

Table 1. Types of potholes found on the study area.

A - Permanent Potholes

1 - Sedge-whitetop

2 - Cattail

3 - Bulrush

4 - Zones of emergents intermixed or denuded

B - Semipermanent Potholes

1 - Sedge-whitetop

2 - Cattail

3 - Bulrush

4 - Zones of emergents intermixed or denuded

C - Temporary Waters

D - Artificial Dugouts without Flooded Ends

Depth -- The depths (Table 2) which were all measured from August 20 to August 27 are not entirely accurate, as the bottom soil in these areas was extremely soft and there was usually some question when the bottom had been reached. However, they are of some value for purposes of comparison.

Permanence -- Those potholes were rated as permanent which might be expected to contain water through the course of the summer even in relatively dry years. This is an extremely indefinite criterion, particularly when one considers the statements by local residents that in 1938 the only open water on the study area was in one artificial dugout. In actual practice potholes were rated as permanent which had a very definite growth of emergent vegetation at the margins and open water at the center making up 10 percent or more of the total area. In one case, where the vegetation had been removed by excessive grazing, the permanency was

Table 2. -- Physical Data Relating to Pothole Types.

| Type | Number of Potholes | | | Area (acres) | | | | Depth (feet)* | | | Drop in Water Levels (Inches) 7/30 - 8/21 | | | Average Percent of Open Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Cover Mapped | With water gauges | Average | Total | Maximum | Minimum | Average | Minimum | Maximum | Average | Minimum | Maximum | |
| A 1 | 25 | 25 | 19 | 1.75 | 43.8 | 3.9 | 0.3 | 1.98 | 1.2 | 3.0 | 4.3 | 3.1 | 5.1 | 59 |
| A 2 | 6 | 6 | 6 | 1.42 | 8.5 | 2.3 | 0.7 | 2.30 | 2.0 | 3.0 | 4.5 | 3.3 | 5.8 | 47 |
| A 3 | 4 | 4 | 4 | 5.60 | 23.4 | 10.9 | 3.1 | 2.43 | 1.2 | 3.5 | 4.0 | 3.6 | 4.4 | 54 |
| A 4 | 7 | 7 | 5 | 1.26 | 8.8 | 2.8 | 0.2 | 1.39 | 0.7 | 2.0 | 5.0 | 4.7 | 4.8 | 35 |
| B 1 | 37 | 9 | 7 | 0.45 | 16.6 | 1.7 | 0.2 | 0.4 | 0.0 | 1.0 | 8.0 | 5.5 | 11.4 | -- |
| B 2 | 6 | 1 | 0 | 0.61 | 3.7 | 2.2 | 0.2 | 0.0 | --- | --- | --- | --- | --- | -- |
| B 3 | 3 | 0 | 0 | 0.30 | 0.9 | 0.4 | 0.2 | --- | --- | --- | --- | --- | --- | -- |
| B 4 | 6 | 1 | 1 | 0.45 | 2.7 | 0.6 | 0.1 | 0.5 | --- | --- | 10.0 | --- | --- | -- |
| C | 30 | 2 | 2 | 0.23 | 6.9 | 0.4 | 0.1 | 0.0 | --- | --- | 13.0 + | 11.0 | 15.0 + | -- |
| D | 3 | 0 | 0 | 0.25 | 0.8 | 0.25 | 0.25 | --- | --- | --- | --- | --- | --- | -- |
| Total | 127 | 55 | 44 | 0.92 | 116.3 | | | | | | | | | |

* Depths measured August 20 - 27.

difficult to determine, but since there were no traces of emergent vegetation at the center to indicate that the water had been shallow enough within the previous few years for it to have become established, the pothole was considered permanent. After years of extreme drought, this criterion probably could not be used, since even those areas here classified as permanent might be choked with emergents.

Potholes were classified as semipermanent if they could be expected to go dry during the summer except in years of abnormally high rainfall. The criterion in this case was the presence of a well-developed stand of emergent vegetation with less than 10 percent of the area open water.

Temporary waters are those with no well-developed emergent vegetation, but which contained water in the spring and after heavy rains.

Dugouts were small permanent water areas made during the drought years for the purpose of watering stock when natural potholes were drying up. Those which had overflowed at the ends, so that their margins were no longer steep-sided, were classed as natural potholes of one of the above types.

Vegetation -- The original outline maps of the potholes were taken into the field and the vegetation was sketched on them while notes were made on the relative abundance and density of the various species.

Four principal vegetation types were distinguished in the permanent and semipermanent potholes. There was a great deal of overlap between them, and more or less arbitrary lines have been drawn for purposes of description and discussion. Plate III shows the distribution of all but the temporary waters.

## The Pothole Types

Type A1 -- The permanent sedge-whitetop potholes appeared rather barren at first glance. The border vegetation was dominated by a mixture of whitetop grass (Scolochloa festucacea)and a large sedge (Carex sp.) about 3½ feet high usually growing separately in clumps at the edge of the open water and merging into a solid stand near and on the shore.

Table 3 shows the species and occurrence of the vegetation found in this type of pothole, listed in the order of their abundance. The first column shows the percent occurrence of each species present. Thus, cattail (Typha latifolia) was found in 68 percent of these areas. The second column represents the average percentage of the vegetation zone occupied by the species. Thus, cattail occupied 3 percent of the area covered by emergent vegetation. The third column shows the average density at which the species grew in each pothole type. This has been rated subjectively from I (sparse) to III (dense).

Frequently there were scattered clumps of cattail or hardstem bulrush (Scirpus acutus) at the edge of the open water. The only other commonly abundant species were lesser duckweed (Lemna minor) and star duckweed (L. trisulca). A mixture of spikerush (Eleocharis spp.) and rush (Juncus spp.) sometimes occurred as a ring on the drier side of the sedge-whitetop zone, but in most cases the sedge-whitetop merged directly into the more-moisture-tolerant weeds and grasses of the prairie, or with a willow zone. Some of these areas showed a distinct band of wild barley between the emergent vegetation and the prairie.

Table 3. Vegetation found in sedge-whitetop potholes.

| Species | Occurrence (Percent of potholes) | Average percentage of vegetation zone* | Average density* |
|---|---|---|---|
| Fluminea festucacea | 100 | 45 | I - II |
| Carex spp. | 100 | 41 | II |
| Lemna trisulca | 96 | 65 | II |
| Lemna minor | 96 | 28 | I - II |
| Typha latifolia | 68 | 3 | I - II |
| Eleocharis sp. - Juncus sp. | 44 | 8 | II |
| Hordeum jubatum | 36 | 18 | II |
| Scirpus validus | 24 | | |
| Green algae | 20 | | |
| Salix spp. | 16 | | |
| Potamogeton spp. | 12 | | |
| Scirpus acutus | 12 | | |
| Sium suave | 8 | | |
| Myriophyllum spp. | 8 | | |
| Beckmannia syzigachne | 4 | | |
| Utricularia vulgaris | 4 | | |
| Phragmites communis | 4 | | |
| Glyceria spp. | 4 | | |

* Listed only when occurrence was over 30 percent.

The vegetation of these potholes varied considerably both in density and the extent to which the plants grew in clumps in the deeper water. Pure stands of whitetop were generally more dense and solid than were mixtures of whitetop and sedge or pure stands of sedge which tended to grow more sparsely and form clumps. The vegetation of a typical type A1 pothole (No. 40) is shown in Plate IV.

Type A2 -- The basis of differentiation into this type was the prominence of cattail. The dividing line was arbitrarily assumed to be reached when cattail occupied 30 percent or more of the zone of emergent vegetation.

Table 4 shows the species of vegetation found in this type. In general, there was an increase in the occurrence of submerged aquatics particularly water milfoil (Myriophyllum spp.). Lesser duckweed was less abundant than in the sedge-whitetop potholes, but star duckweed was still abundant. Wild barley was often prominent on the immediately adjacent prairie. These potholes varied considerably in character. Number 39 was merely a type A1 pothole with cattail added. The shoreline cover was whitetop and sedge growing out to a depth of about 15 inches followed by a narrow strip of nearly open water followed by a ring of cattail about 6 yards wide growing in water up to 20 inches deep. Star duckweed was the most abundant submerged aquatic, and lesser duckweed was the next most abundant plant of the open water. This area had been lightly grazed in the spring and fall only.

Table 4. Vegetation found in cattail potholes.

| Species | Occurrence (Percent of potholes) | Average percentage of vegetation zone | Average density |
|---|---|---|---|
| Typha latifolia | 100 | 45 | II - III |
| Lemna trisulca | 100 | 45 | II |
| Carex spp. | 100 | 16 | II |
| Eleocharis spp. - Juncus spp. | 83 | 15 | II |
| Hordeum jubatum | 83 | 52 | II |
| Fluminea festucacea | 83 | 20 | II |
| Lemna Minor | 83 | 7 | I |
| Myriophyllum spp. | 67 | 30 | III |
| Scirpus validus | 50 | 4 | I |
| Potamogeton spp. | 33 | 3 | I |
| Green algae | 33 | 4 | II |
| Scirpus paludosus | 33 | 1 | I |
| Water moss | 17 | | |
| Coratophyllum demersum | 17 | | |
| Utricularia spp. | 17 | | |
| Utricularia vulgaris | 17 | | |

Most of these potholes were ringed by a dense zone of cattail merging into a zone of spikerushes. The submerged vegetation was dominated by water milfoil, which partially covered the surface. Pondweed (Potamogeton spp.), star duckweed, and a trace of lesser duckweed were also present. The distribution of plant species in this type is illustrated in Plate V, a cover map of pothole 14.

There was a more or less continuous trend from the pure sedge-whitetop to the pure cattail areas and the borderline between types A1 and A2 was extremely vague. However, since these different types varied greatly in the amount of use they received by waterfowl, it was deemed necessary to make an arbitrary division into two types for purposes of study.

Type A3 -- Permanent hardstem-bulrush potholes showed a marked decrease in the importance of duckweeds and an increase in other submerged aquatics including pondweeds and green algae (Table 5). The surface of three of these areas became choked with these plants by late summer. The most prominent emergent was hardstem bulrush which made up at least 30 percent of this zone. Cattail was also abundant, growing as a ring outside the hardstem bulrush and mixed with softstem bulrush (Scirpus validus) and/or whitetop. Cattail islands were intermingled with islands of hardstem bulrush. Each pothole of this type had a well-developed zone of spikerush and rush, which included whitetop in two cases, and was surrounded by a ring of wild barley.

The deepest of these potholes (No. 34), where the hardstem bulrush grew in 1 to 3 feet of water, had a sparser growth of hardstem bulrush than did the others of this type. A band of whitetop had become established on the north end and made up all the emergent vegetation of that shore. Some of these potholes contained a large amount of green algae which choked the surface by late summer. Others contained water milfoil in large quantities which could be seen covering the surface. A mixture of cattail, rush, spikerush, and sparse whitetop formed the shallow-water and moist-soil vegetation of two of these potholes (Nos. 2 and 5). A well-developed stand of whitetop grew in 2 feet of water in pothole No. 1, in which hardstem bulrush was the most prominent species. This stand grew all along one shore for a distance of about 200 yards in deeper water than the bulrush. Plate VI indicates the relations of the zones of vegetation in pothole No. 2. As can be seen, these potholes were highly variable in the density and composition of their vegetation. However, there seemed to be little relationship between these and either the cattail or the sedge-whitetop potholes.

Type A4 -- These potholes with zones of emergents intermixed or denuded had in common a conspicuous lack of zonation of the emergent vegetation as shown in Plate VII.

As shown in Table 6, star duckweed was conspicuous in this type as was water milfoil which had choked much of the surface of three of these potholes by early August and was prominent in three others. The emergent vegetation showed no single dominant species common to the type although there were usually clumps of cattail, hardstem bulrush, and softstem bulrush interspersed with slough grass (Beckmannia syzigachne) and other species in lesser amounts. The ring of rush and spikerush surrounding these potholes was conspicuous. Whitetop and sedge, which occurred often, were found mainly on those portions of the margins which were protected from grazing. Wild barley was conspicuous surrounding the zone of emergents.

Table 5. Vegetation found in bulrush potholes.

| Species | Occurrence (Percent of potholes) | Average percentage of vegetation zone | Average density |
|---|---|---|---|
| Scirpus acutus | 100 | 31 | II |
| Hordeum jubatum | 100 | 26 | II |
| Fluminea festucacea | 100 | 23 | II |
| Eleocharis spp. - Juncus spp. | 100 | 16 | II |
| Typha latifolia | 100 | 16 | II |
| Myriophyllum spp. | 75 | 27 | I - II |
| Potamogeton spp. | 75 | 20 | I |
| Green algae | 75 | 36 | II |
| Utricularia vulgaris | 50 | 11 | I |
| Scirpus validus | 50 | 8 | I |
| Phragmites communis | 50 | 3 | I |
| Carex spp. | 50 | 2 | I |
| Lemna trisulca | 25 | | |
| Lemna minor | 25 | | |
| Scirpus paludosus | 25 | | |
| Typha angustifolia | 25 | | |

A dense stand of alkali bulrush (Scirpus paludosus) grew as a pure stand on one shore of pothole No. 4. This area also supported good stands of hardstem bulrush and some cattail. Again the surface was choked with water milfoil. One pothole had an abundance of water parsnip (Sium suave) yet contained a clump of whitetop as well as softstem bulrush, hardstem bulrush, and cattail, and was surrounded by only a narrow border of spikerush. Water milfoil covered the surface of this area by late summer.

Pothole No. 25 at first glance appeared to be unrelated to any others on the area since it supported little emergent vegetation. It was subjected to extremely heavy grazing pressure and was apparently similar to others of this type but had been completely grazed out early in the summer. The vegetation consisted mainly of grazed stems of softstem and hardstem bulrush, burreed (Sparganium spp.), and water plantain (Alisma plantago-aquatica). These stems were overtopped in late summer by spikerush and small clumps of slough grass.

Table 6. Vegetation found in potholes with vegetation diversified or nearly absent.

| Species | Occurrence (Percent of potholes) | Average percentage of vegetation zone | Average density |
|---|---|---|---|
| Eleocharis spp.- Juncus spp. | 100 | 35 | II |
| Myriophyllum spp. | 86 | 34 | III |
| Scirpus validus | 86 | 5 | I - II |
| Lemna trisulca | 71 | 33 | II |
| Carex spp. | 71 | 13 | II |
| Beckmannia syzigachne | 71 | 6 | II |
| Scirpus acutus | 71 | 3 | II |
| Typha latifolia | 71 | 11 | II |
| Fluminea festucacea | 57 | 13 | I |
| Hordeum jubatum | 57 | 26 | II |
| Sium suave | 57 | 5 | I |
| Alisma plantago-aquatica | 57 | tr | |
| Potamogeton spp. | 43 | 21 | III |
| Lemna minor | 43 | 1 | I |
| Scirpus paludosus | 14 | | |
| Hippuris vulgaris | 14 | | |
| Cicuta spp. | 14 | | |
| Ranunculus spp. | 14 | | |
| Sparganium spp. | 14 | | |
| Green algae | 14 | | |

These potholes in their species composition and in the character of their submerged vegetation bore some resemblance to both the cattail and the bulrush potholes, but they appeared to belong in a separate class because of their lack of zonation.

Although from the standpoint of vegetation, the semipermanent potholes could be put in one of the above classes, the difference in the stability of the water supply had such importance for ducks that they have been grouped separately and have been placed in types similar to those in group A. However, owing to the absence of open water, their submerged aquatic vegetation was much reduced.

Type B1 -- The sedge-whitetop semipermanent potholes were almost identical to the permanent except for the lack of open water and consequent scarcity of submerged aquatics. Lesser duckweed grew in many of these even though some went dry during July and again late in August. Other submergent aquatics were rare. Some areas of this type were completely overgrown with nearly pure whitetop while others supported pure sedge or mixtures of sedge and whitetop. In most cases the transition from aquatic species to prairie was similar to that of the permanent areas. However, there were cases where the rapid recession of water in the spring permitted cultivation beyond the natural margins and the transition was lacking so that pure whitetop was directly adjacent to small-grain crops.

Type B2 -- Semipermanent cattail potholes differed little from the permanent type, except that there was generally a considerable growth of softstem bulrush mixed with the cattail.

Type B3 -- These differed markedly from Type A3, as they contained no hardstem bulrush. They supported a mixture of softstem bulrush, cattail, and spikerush, in which the bulrush was most prominent. The cover was generally somewhat sparser than in Type B2.

Type B4 -- The semipermanent potholes with scattered vegetation were comparable to permanent waters of the same type. Burreed was often abundant as were water parsnip, water plantain, spikerush, and slough grass. Some of these areas supported predominately spikerushes and rushes with some softstem bulrush. At first glance some appeared to be temporary areas; but when aquatic species were present, they were classed as semipermanent.

Group C -- The temporary waters have not been broken down into types. They varied from islands of willow in cultivated fields through several forms of wet meadow to cultivated fields which were flooded in the spring and after heavy rains. Since these areas had a certain value to waterfowl they have all been considered potholes, although they have not been shown on the map of the study area.

Group D -- Dugouts were artificial water areas most of which were dug during the drought years with the aid of the P. F. R. A. (Prairie Farmers' Rehabilitation Act). They were about 170 by 60 feet in area and usually 10 feet deep. The soil was removed by means of drag lines and piled up in high spoil banks on two sides. Two on the study area were dug in places where there had previously been potholes and have been flooded over since the drought. The dugouts themselves supported little vegetation other than water milfoil near the sides and some sparse emergents, generally sedge and spikerush, along the banks.

## Vertebrate Species Found in Potholes

Waterfowl seen in the area were Mallard (Anas platyrhynchos), Gadwall (Anas strepera), Pintail (Anas acuta), Green-winged teal (Anas carolinensis), Blue-winged teal (Anas discors), Baldpate (Mareca americana), Shoveller (Spatula clypeata), Redhead (Aythya americana), Canvasback (Aythya valisineria), Lesser scaup (Aythya affinis), and Ruddy duck (Oxyura jamaicensis).

Other birds conspicuous in the potholes were Coot (Fulica americana), Horned grebe (Colymbus auritus), Pied billed grebe (Podilymbus podiceps), American bittern (Botaurus lentiginosus), Virginia rail (Rallus limicola), Sora rail (Porzana carolina), Black tern (Chlidonias niger), Long-billed marsh wren (Telmatodytes palustris), Short-billed marsh wren (Cistothorus platensis), and Redwinged blackbird (Agelaius phoeniceus). Muskrat (Ondatra zibethica) and Mink (Mustela vison) signs were also seen. Other species of considerable direct importance to waterfowl, although not occupying the potholes, were the skunk (Mephitis mephitis) and the crow (Corvus brachyrhynchos).

## Factors Affecting Vegetation Types

There now arises the question: What causes the differentiation into vegetation types? The normal hydrarch succession as described by Weaver and Clements (1938) has been affected by land use and other factors to the point where there is a great variability in the vegetation of water areas. The fundamental processes remain unchanged. Submerged species give way to floating plants and emergents in the shallower waters, and the emergents give way to the sedge-meadow species in the moist soil of the shorelines.

In addition to the processes which build up the bottom, making conditions unsuitable for one group of plants and creating conditions favorable for the invasion of another group, the water levels in these areas are extremely unstable. This instability may be as important as the soil-building processes in determining the successional stage of any portion of a water area. One year this portion may be covered by 12 inches of water and be typical of the floating stage; another year it may be dry and more typical of the sedge-meadow stage.

A consideration of the factors which may control the species composition of the various successional stages is given below.

Area -- The area of the pothole (Table 2) seems unimportant as there was extensive overlap between the maxima and minima of the four types. A possible exception is Type A3, which was not found in potholes less than 3.1 acres in area. However, this was only slightly above the maximum for Types A2 and A4 and below the maximum for A1. Moreover, Type A3 potholes of smaller size were known to occur outside the boundaries of the study area.

Depth -- There was an overlap of water depths in potholes of the four types. There was at least one pothole of each type between 1.2 and 2.0 feet in depth as measured in late August. These two figures represent the greatest minimum and the lowest maximum recorded depth for these types.

Rate of Water Loss -- With the exception of types A3 and A4, there was a similar overlap in this factor. The maximum of the former was less than the minimum of the latter. However, the difference appears relatively slight.

Soils and Chemical Tolerance -- A detailed soil map of the region was not available but it must be assumed that the soils of the region were somewhat heterogeneous and the chemistry somewhat variable. It is unfortunate that there were not facilities available for making a study of water chemistry. However, this was apparently not the major factor controlling the distribution of those species of vegetation found on the study area since the different vegetation types were represented not only in closely adjacent potholes but in different parts of the same pothole.

The plant species found in the North Dakota lakes described by Metcalf (1931) and the Minnesota lakes studied by Moyle (1945) were compared with the species found on the study area. The distribution of the species on the study area did not indicate that water chemistry was an important factor since there were cases where species at both ends of the scale of tolerance were found in the same area. Apparently the Minnedosa potholes were all within the range of tolerance of these species.

Ice Action -- Although this might presumably have had some effect on emergent vegetation, there is no reason to suppose that it was important in relation to species distribution. Table 2 shows that the vegetation types were all distributed in potholes of nearly the same size and depth and which would presumably be subject to similar conditions with regard to ice.

Grazing -- Joseph A. Calen, who owns the land on the northern third of the study area, was kind enough to furnish information based on detailed records concerning the grazing use of the study area for the past 8 years (Plate VIII). Since an accurate forage inventory was impracticable, the grazing use has been rated subjectively on the basis of entire units without attempting to differentiate the degrees of use of the various parts of each unit. The distinction between "spring and fall" and "all season" grazing is apparently the most important from the standpoint of the aquatic vegetation. The "all season grazing" was heaviest at the time these plants were making their most rapid growth and producing seed.

A comparison of Plate VIII with Plate III showing the distribution of the pothole types indicates that grazing may have had an important influence on vegetation. The sedge-whitetop potholes were in units which, for the past 8 years, have been lightly to moderately grazed only in the spring and fall. All of the Type A4 potholes (those with the zones of emergents intermixed or denuded) were in units moderately to heavily or very heavily grazed throughout the growing season. Most of the potholes in which cattail and bulrush were predominant occurred in units which were grazed to a similar extent and on those which had been heavily grazed in the past and protected for the last few years.

The effect of grazing on the vegetation can be further demonstrated by cases where fence lines passed through potholes. Pothole No. 2 (Plate VI) has the hardstem-bulrush and cattail cover of a Type A3 pothole to the left of the fence where there had been very heavy all-season grazing in alternate years. The cover to the right of the fence which had not been grazed is nearly pure whitetop, or Type A1.

A striking example is furnished by potholes Nos. 11 and 12 (Plate IX). Apparently these were once a single pothole that had been bisected by the road. No. 12 had been subjected to moderate to very heavy season-long grazing while No. 11 had been only lightly grazed in the spring and fall. No. 12 was choked with water milfoil and buttercup (Ranunculus spp.), softstem bulrush, water plantain, cattail, spikerush, and rush, with some sparse whitetop in the background. No. 11 had a cover of sedge and whitetop except for the mown area which bore spikerush. The water surface was clear of weeds.

Plate VII (the vegetation of pothole No. 4) shows the sedge and whitetop cover on that portion of the pothole which was protected from grazing while the remainder supported Type A4 vegetation. Similar conditions existed in potholes Nos. 3, 5, 6, 10, and 25.

Two of the ways in which grazing by livestock might have influenced pothole vegetation are by affecting siltation and turbidity of the potholes, and by actual disturbance of the vegetation.

In this region, the use of land for permanent pasture served to reduce siltation, as erosion from the cultivated slopes surrounding potholes was considerable while erosion from pasture land was apparently slight. Siltation was apparently a minor factor in the potholes themselves. The dense growth of weeds, grasses, and moist-soil plants served to trap even the great amounts of soil washed from the cultivated slopes by the exceptionally heavy rain of July 28. At this time, silt was found as deep as 8 inches surrounding some of the potholes; yet it had not penetrated more than a foot into this border of vegetation, and only potholes Nos. 20 and 33 were found to be perceptibly roiled.

Since there was a possibility that siltation was greater in other years, the bottoms of those potholes which were cover-mapped were rated as firm or soft. Suprisingly enough, most of the firm bottoms were Type A1, although each type was represented by at least one firm and one soft bottom. Apparently, neither siltation nor turbidity is an important factor.

Disturbance of the vegetation was apparently the most important influence of grazing. Wherever sedge was available to livestock, it was readily consumed. Whitetop, with the exception of cases where it grew as sparse stands with coarse stems in the deeper waters, was apparently as readily eaten. Other emergent vegetation was not disturbed unless upland forage became scarce as in the case of pothole No. 25. Thus sedge and whitetop were either weakened or destroyed under constant grazing.

Reeve (1949), in a study of the muskrat marshes of Manitoba, found that sedge (probably Carex rostrata) was able to crowd out other emergents owing to its extensive root system. On the Minnedosa study area, whitetop apparently competed on an equal basis with sedge and, if left in an undisturbed condition, these two species were able to crowd out other emergents. When a pothole was grazed or trampled, these species were eaten by cattle and either retarded in their development or removed so that a bare area was created. This not only allowed cattail and bulrush to spread by rhizome growth, but permitted sexual reproduction of these species during times of low water.

Muskrats -- These animals cut a fairly large amount of sedge and whitetop late in the summer and may have been largely responsible for the small clumps of cattail and bulrush growing on the Type A1 potholes. They removed the cover at the time when the waters would normally have been receding, leaving bare mud flats suitable for germination of cattail and bulrush seeds. No seedlings of cattail or hardstem bulrush were seen during the summer of 1949, probably because of the heavy rains in late July which raised the water levels and prevented the exposure of mud banks.

Mowing -- This practice as observed in 1949 affected only vegetation growing on moist soil and did not greatly disturb the potholes. Spikerush and rush were able to attain temporary dominance of the mown area, but were soon replaced by whitetop and sedge which recovered rapidly after a single cutting. In drier years the entire pothole is often mown, and the effect might be more pronounced.

Burning -- Since all burning observed on the study area was done in the fall of 1948, this practice resulted in conditions similar to those produced by mowing and was not seen to affect plants growing in the water; whitetop and sedge became reestablished early the following spring.

Relative Age -- All potholes on the study area were presumably formed within the same period and have experienced the same climatic changes since formation.

Origin of the Present Vegetation -- It was not possible to determine exactly how the bulrush and cattail originally became established. If it is borne in mind that all these potholes were dry during the drought, two alternatives present themselves.

The first is that as the water areas dried up they were gradually invaded by sedge and whitetop which formed a meadow. In heavily grazed areas, this meadow might have been grazed short and continually trampled, creating a bare or nearly bare area, and allowing the establishment of hardstem bulrush and/or cattail. This does not seem likely if one considers the statement made by one of the farmers on the study area that the only crops he was able to raise during the drought came from the bottoms of potholes. This cultivation should certainly have created as much or more of a bare area than grazing by livestock. It also seems unlikely that the stock could completely remove the vegetation from such a lowland area. Such meadows occurred in 1949 in the bottoms of dried-up semipermanent potholes. In spite of severe grazing pressure, they still maintained a solid cover of vegetation.

The more probable alternative is that these potholes dried too rapidly for the sedge and whitetop to invade their centers. This would have left extensive bare mud flats furnishing seed beds for cattail and hardstem bulrush. Those that have not been heavily grazed since then may have been reinvaded by sedge-whitetop through rhizome competition. Those that have been grazed may have retained cattail or hardstem-bulrush vegetation through weakening of the sedge and whitetop by repeated cropping. Apparently at times of receding water levels in late summer, new stands have been developed in some of the Type A4 potholes which show a lack of zonation and have dense clumps of cattail and hardstem bulrush (Plate VII). This may have been caused by a local removal of less palatable emergent vegetation by livestock during periods when the pastures were overgrazed.

## III. METHODS OF STUDY

Mapping -- Before the study area was visited, a rough sketch of it was made to the scale of 6" = 1 mile from an aerial photograph and was checked in the field during the first coverage of the area. This was marked off in $\frac{1}{4}$-inch grids so that any point on the map could be located by its grid coordinates. A copy was carried in the field at all times and all observations and objects such as potholes, ducks, and nests were located and referred to by their grid coordinates.

Nest Hunting -- As soon as the study area was selected, nest hunting began in order that broods might be marked by dyeing the young in the egg so that their subsequent movements might be observed. Coverage of all water areas was the first job and consisted of thorough inspection of the emergent vegetation of potholes. During this search most diving-duck nests were located and counts were made of the waterfowl population of the area. This coverage was made in the 7 days from June 12 through June 18. From then until July 12, most of the mornings were spent in hunting for river-duck nests by traversing on foot the better nesting cover of the area, while afternoons and evenings were spent in observation of broods.

In conjunction with nest hunting a certain amount of crow control was carried on. This was felt desirable since it seemed probable that once a crow had seen a hen flushed and the nest exposed, it would be likely to return and destroy the nest. The crow control was not intended to reduce the population and consisted mainly of driving off crows which tended to follow

the observer and watch his movements. This was easily done by shooting at them with a .22 caliber rifle which kept most of them at such a distance that they could not watch proceedings. Nesting crows in some cases had to be destroyed, as they could not be driven from the vicinity and it was felt that hunting duck nests in their presence would lead to predation. Later it was found that if all the young of a crow nest were destroyed, the parents left the area. This was much more efficient, as it took considerable time to shoot the adults with a rifle. Eight crow nests were destroyed while 7 adults and 18 young were shot from June 12 to June 26. Although few crows were killed by the use of the rifle, its great "scaring" range and easier portability made it superior to a shotgun.

Locating Marked Broods -- As soon as the clutches of marked eggs had hatched, searches were started for the broods. At first this was done intensively, and thorough searches were made of all potholes to which the broods might have gone after leaving their nests. This method produced no results and was abandoned in favor of making as extensive a coverage as possible of the entire area.

Searches were conducted in three ways. The usual method consisted of traversing the margins of potholes on foot, moving slowly but creating considerable disturbance in an effort to drive broods into the open. Slow movement was necessary since birds which were approached too fast appeared to take cover and hide rather than flush into the open. This depended to some extent on the weather and the time of day. In the early morning or in the evening the birds were easier to flush than in the middle of the day. Still days were better than windy days, and most of the birds refused to flush if the wind was over 15 miles an hour. Some broods, particularly mallard and pintail, tended to circle the pothole ahead of the observer and often could be seen along the opposite shore sneaking through the marginal vegetation. For 9 days, at the time when most of the broods were hatching, Eugene F. Bossenmaier from the Delta Station furnished valuable assistance. Two men were not only able to cover a pothole twice as fast as a single man, but also could do it much more thoroughly. If they worked down opposite margins and met at the far side, any broods moving ahead of one man were blocked by the other and could be seen and sometimes captured. This was particularly successful when the drive was planned so that the two men met on a relatively straight shoreline where cover was not too dense.

A second method consisted of a walking tour of the area to be searched, either in the early morning or in late evening. If the approach to a pothole was rapid and concealed the broods were often surprised on the open water and could be examined before they could reach cover. This was a rapid method and a large number of broods were seen in this way. But the coverage given to an individual pothole was not thorough since it was only on rare occasions that all broods were in the open at the same time.

The most thorough but time-consuming coverage was obtained by extended observation of a single water area during the early morning or in the evening. Little could be seen for the first 30 minutes, since the birds apparently became alarmed regardless of the concealment or silence of the approach. Ducks without young showed no sign of disturbance and would remain feeding or resting close to the observer both during and after the approach. Brood hens were apparently more wary and broods were rarely seen in the open for some time after the approach. After the observer had waited in a concealed position for 30 minutes to an hour, they began to emerge and in the course of the evening most of them could be seen. Apparently, even though the ducks could not see or hear the observer approaching, they became alerted, possibly by the calls of the other birds which the observer could not avoid disturbing and which required some time to become used to his presence.

To extend the area of search, the roads along section lines within 2 miles of the area were cruised by automobile in the early morning or evening. This gave an incomplete but very rapid coverage of a wider area. For a week in mid-July, walking tours were made covering all potholes within half a mile of the study area.

Attempts were made to work both early morning and late evening, but this proved impracticable and, after a time, evening work was selected as more effective than morning. There appeared to be a greater species variation in the period of activity in the morning than in the evening since broods were seen roosting as much as an hour after sunrise, while in the evening all were active until it became too dark to see.

Aging and Counting Broods -- In addition to the recording of movements of marked broods, all broods seen were noted as to species, location, number of young, and age. Three age classes were used, as described by Stoudt (1940). Class I were those young that were still in the down. Class II were partially feathered. Class III had nearly all their body feathers but were not yet ready to fly. Counts of the number of young were graded as good, fair, or poor. In this way, movements of unmarked broods could be traced. If only one brood of a certain species, age, and number was seen in the vicinity, and it could be repeatedly located, it was assumed to be the same brood. The absence of a previously observed brood from a pothole was taken as evidence that it had moved away from it, while the appearance of a new brood in a previously checked area was accepted as evidence that it had just moved in. These observations taken individually are not conclusive evidence of movement, but they occurred with such regularity and matched so closely the behavior of marked broods, that there seems to be no question of the validity of the information they provided.

Cover Mapping -- In order to obtain data on the preference of broods for the various vegetative types previously described, cover maps were made of 55 water areas. These included all the permanent (Group A) potholes, most of the semipermanent (Group B) potholes, and a few temporary (Group C) potholes, including some on which no ducks were found. Most of the data on these maps have been discussed already. Rough estimates were made of the use of the area by muskrats, coots, grebes, and black terns.

Weather Data -- Notes taken in the field contain information on the time of day and the weather. Temperature, wind, visibility, and cloud cover were noted, in order that the effects of these factors on the behavior of the ducks might be evaluated.

## IV. MOVEMENTS OF BROODS

### Observed Movements of Individual Broods

In spite of the small number of broods successfully marked and the difficulty experienced in locating them after hatching, the information derived from the five broods which were located is of considerable aid in interpreting data gained from the population as a whole.

Included with the following case histories of marked broods shown in Plate X are summaries of information on the movements of individual unmarked broods. Only those broods have been included which could be surely recognized

as described under "Methods." The numbers of broods known to reside in only one pothole throughout their preflight development are included after the summaries for each species.

Canvasback -- The first marked brood observed was that of a canvasback, colored green, hatched June 15 from a nest located in the small semipermanent cattail pothole southeast of No. 5. It was located the following day on pothole No. 5, where it remained until some time between June 26 and June 29. On the latter date it was seen on pothole No. 1 where it could be identified until July 7, which was the last time the color was observed. However, a brood which can safely be assumed to be this one remained there until July 12. On July 13 a thorough coverage of this pothole as well as all areas within one-half mile failed to reveal the brood and none that could possibly be this one was ever seen again. This brood was 27 days old (Class II) when last seen, and was still accompanied by the hen. The minimum distance traveled by this brood was 0.28 miles in 28 days.

A second canvasback brood of three that had been dyed with Ponceau SX hatched on June 30 from a nest in a cattail clump at the north end of pothole No. 33. The brood remained on this pothole until July 14. In fact, on July 7 after dark, they were actually found on the nest, where the hen was apparently brooding them.

From the age of 2 to 4 weeks this brood was seen on four different potholes, finally returning on August 1 at the age of 32 days to the second one in which it had been observed. At this time the young were Class II and the color of the dye was last seen. They were observed on this pothole seven times between August 1 and the last visit on August 22. At this date (age, 54 days) their flight feathers were almost fully developed and they appeared to be ready to fly. The minimum distance traveled overland by this brood was 0.81 miles in 54 days.

Eight unmarked canvasback broods were recognized in two or more potholes and their movements are outlined below. The dates listed show the first day a change in location was noted. In some cases broods were observed on intervening dates on the pothole last cited.

1. A Class I brood of seven. June 17 - still on nest at Type B1 pothole south of No. 18. June 18 - on pothole No. 33 (not seen again). Travel - 0.18 miles in 2 days.

2. A Class I brood of seven. June 17 - on pothole No. 36. June 26 - on pothole No. 39. June 30 - on pothole No. 40 (last seen). Travel - 0.16 miles in 13 days.

3. A Class II brood of six. June 26 - on pothole No. 36. July 14 - on pothole No. 39. July 22 - the hen and five Class III young were on pothole No. 40, while one Class III young was on pothole No. 39. The hen and the one lone duckling were last seen on this date. July 29 - brood last seen (ready to fly). Travel - 0.16 miles in 33 days.

4. A Class II brood of nine. July 1 - at pothole No. 22. July 5 - at pothole No. 23. July 10 - at pothole No. 21 (last seen). Travel - 0.13 miles in 9 days.

5. A Class I brood of one. July 1 - at pothole No. 33. July 22 - at pothole No. 35 (Class III). July 30 - young last seen (ready to fly). Travel - 0.12 miles in 30 days.

6. A Class II brood of six. July 3 - at pothole No. 29. July 5 - at pothole No. 31. July 6 - at pothole No. 34. July 12 - Last seen. Travel - 0.2 miles in 9 days.

7. A Class I brood of six. July 3 - at pothole No. 13. July 5 - at pothole No. 28. July 6 - at pothole No. 33. July 14 - at pothole No. 35 (last seen). Travel - 0.44 miles in 11 days (0.32 miles in 3 days; 0.24 miles in 1 day).

8. A Class II brood of five. July 7 - at pothole No. 22. July 14 - at pothole No. 21. July 16 - at pothole No. 24. July 22 - at pothole No. 40. August 2 - at pothole No. 34. August 5 - Last seen. Travel - 0.58 miles in 29 days.

These 10 broods traveled overland a total of 2.88 miles in the 218 days that they were observed for an average of 0.013 miles a day. No broods of this species were known to use one pothole for more than 23 days (less than half of the probable period of preflight development).

Redhead -- A brood of four newly hatched redheads dyed with Croceine scarlet was seen July 2 at the nest on the west end of the type B2 pothole south of No. 15. On July 14 the hen and three marked young were seen on pothole No. 35, and on August 12 it was seen on pothole No. 36. This brood traveled at least 0.75 miles in 58 days.

Two unmarked redhead broods were observed in their movements as outlined below:

1. A Class I brood of eight. July 14 - seen at pothole No. 34. July 19 - seen at pothole No. 33. August 15 - at pothole No. 35 (not seen again). Travel - 0.32 miles in 32 days.

2. A Class II brood of nine. August 14 - at pothole No. 34. August 15 - at pothole No. 35. August 18 - hen last seen. August 22 - brood last seen. Travel - 0.07 miles in 8 days.

These three broods were observed to travel a total of 1.14 miles in 96 days for an average of 0.012 miles a day. No redhead broods were known to remain in one pothole longer than 31 days.

Baldpate -- A nest of baldpate just northwest of pothole No. 33 containing nine normal eggs and one midget egg was colored with Ponceau SX on June 22. When revisited on July 8, the nest was listed as destroyed. However, on July 10, the well-colored brood of six young was seen on pothole No. 36 and was estimated to have hatched on July 5. For some reason, this brood rejected pothole No. 33 which was heavily used by other broods, including one baldpate, and moved 0.16 miles farther to pothole No. 36. Only the feigning hen was seen to indicate the presence of the brood from July 28 until August 10 when the young no longer showed any color. However, the constant presence of the hen indicated that the brood had not moved. On August 21, the hen was still with the young which appeared ready to fly at the age of 47 days.

This brood moved overland at least 0.2 miles.

Three unmarked baldpate broods were seen to move overland as shown below:

1. A Class I brood of 10. July 14 - found on pothole No. 40. July 22 - found on pothole No. 39. (No good counts after this date.) August 16 - hen

last seen. August 27 - brood still here and ready to fly (last visit). Travel - 0.08 miles in 44 days.

2. A Class I brood of five. July 14 - at pothole No. 37. July 22 - one young remaining. (This is undoubtedly the same brood since the others in this area were known at this time.) July 28 - at pothole No. 35. August 18 - hen last seen. August 27 - one Class III young still here (last visit). Travel - 0.04 miles in 44 days.

3. A Class I brood of nine. July 23 - at pothole No. 20. August 2 - at pothole No. 21. August 4 - last noted (became confused with another brood). Travel - 0.07 miles in 12 days.

These four broods, observed for a total of 147 days, traveled overland only 0.19 miles for an average of 0.001 miles a day. No broods of this species were seen to fly, but three out of eight broods on the area were known not to have moved at the termination of the study, when they were nearly ready to fly.

Pintail -- The eggs in a pintail nest midway between potholes Nos. 4 and 5 were colored red with Ponceau SX on July 3 and hatched about July 7. This brood was seen only once, on July 23, when four brilliantly colored young were found on pothole No. 20. This was judged a poor count as they were driven from the emergent cover and some may have been missed. This pothole was beaten out four times between July 23 and 29. Twice, a pintail hen was seen feigning injury, and on the other two visits a brood was heard peeping and rustling in the cover, but the young were never seen. Further visits in the vicinity failed to reveal any sign of the brood.

This brood traveled 0.42 miles from the nest in 16 days.

Additional information is furnished by two unmarked broods as follows:

1. A Class II brood of nine. June 13 - at pothole No. 33. June 13 - June 29 - location unknown. June 29 - July 11 - back at pothole No. 33. July 14 - at pothole No. 35 (last seen). Travel - 0.12 miles in 31 days.

2. A Class II brood of four. June 17 - at pothole No. 37. June 21 - at Type B1 pothole northwest of No. 37. June 29 - at pothole No. 32. July 5 - at pothole No. 33. July 11 - last seen. Travel - 0.24 miles in 24 days.

These three broods were observed to travel 0.78 miles in 71 days for an average of 0.011 miles a day. No brood of this species was known to occupy a single pothole for more than 14 days.

Mallard — A mallard nest with nine eggs southwest of pothole No. 11 was marked with Fast Green FCF and hatched about June 27. A complete "beatout" of all potholes within a quarter of a mile of the nest failed to reveal the brood. On crossing the prairie 75 yards east of the nest, one of the young, about 1 day old, was found dead in the midst of a colony of thirteen-lined ground squirrels (Citellus tridecemlineatus). The other ducklings of the brood were never located.

Some additional information is provided by the following cases:

1. A Class II brood of four. June 28 - at pothole No. 17. July 16 - at pothole No. 21 (last seen). Travel - 0.16 miles in 18 days.

2. A Class II brood of 11. July 9 - at pothole No. 22. July 10 - at pothole No. 21. July 15 - one young flew. July 23 - at pothole No. 24.

July 29 - at pothole No. 22 (last seen, still accompanied by the hen). Travel - 0.32 miles in 20 days.

These two broods traveled a total of 0.48 miles in 38 days for an average of 0.013 miles a day.

No mallard brood was known to occupy a single pothole for more than 20 days.

Similar information on other individual but unmarked broods is as follows:

Blue-winged teal-- A Class II brood of 13. July 14 - at pothole No. 35. July 22 - at pothole No. 40 (Class III). July 25 - A.M. - on pothole No. 40. July 25 - P.M. - on pothole No. 42. July 29 - hen and six young on pothole No. 42, seven young on pothole No. 40, young ready to fly. Travel - 0.24 miles in 7 days; an average of 0.034 a day.

The longest time a brood of this species was known to occupy a single pothole was 28 days.

Gadwall-- A Class I brood of ten. July 7 - at pothole No. 33. July 11 - at pothole No. 30. Nine young remaining (not seen again). Travel - 0.24 miles in 4 days, or 0.06 miles a day.

Only two gadwall broods were observed and neither spent over 17 days in one pothole.

Ruddy duck-- A Class I brood of nine. July 22 - at pothole No. 39. July 30 - at pothole No. 36. August 27 - last visit. Still nine young. Travel - 0.09 miles in 36 days for an average of 0.002 miles a day.

Of eight broods of this species on the study area, this was the only one known to travel overland.

Shoveller-- A Class I brood of ten. July 19 - at pothole No. 29. July 29 - A.M. - at pothole No. 31. July 29 - P.M. - at pothole No. 29. July 31 - at pothole No. 31. August 1 - A.M. - at pothole No. 31. August 1 - P.M. - at pothole No. 29. August 2 - A.M. - at pothole No. 31. August 2 - P.M. - at pothole No. 29. August 3 - A.M. - at pothole No. 29. August 17 - at pothole No. 30. August 21 - at pothole No. 29. August 22 - at pothole No. 30 (last seen). Travel - 0.7 miles in 34 days for an average of 0.021 miles a day.

The movements of this brood were undoubtedly influenced by the presence of the camp near pothole No. 31. The birds apparently preferred this pothole and were often there in the early morning, but appeared nervous when any activity took place around the camp and usually deserted the pothole for the rest of the day. Although this brood was under rather close observation, there is no indication of the fate of two young which were lost. The maximum time that any shoveller brood spent in one pothole was 16 days.

These examples demonstrate the pattern of brood movement and its direction. It appears to be completely random, as the probable routes taken by broods when placed on a map present a mass of lines running in all directions. There was no general trend of broods toward any one goal. In three cases, broods were known to return to potholes in which they had been previously observed. Broods which may have moved longer distances at a more rapid rate than those described above were not recognized and therefore were not included in the data. Thus the observations recorded may be of shorter than average movements. On the other hand, there is a possibility that disturbance caused by the observer may have caused undue movements.

## Relative Mobility of Species

Duration of Residence -- As a basis for a further study of brood movement, a residence chart was constructed for each pothole on the study area, as shown in Plate XIa for pothole No. 33. Each bar on the chart represents the period that one brood occupied the pothole. Where two bars are on the same level, they represent two visits by the same brood.

Since all broods seen at a pothole and the quality of the coverage given it on each visit had been noted as "complete", "fair", or "visit only", a good estimate could be made of the number of broods occupying a pothole and the length of time they remained there. Thus a brood which was once seen on a pothole but could no longer be found there was assumed to have departed from it. This assumption was made if it was not seen during one "complete" coverage, or two "fair" coverages, or three "visits." The date on which it left the pothole is assumed to be half way between the date it was last seen and the date at which it was judged to be absent. This takes into account the fact that none of those potholes was observed every day and some were not observed for a week or more. The date of arrival of a brood in a pothole was calculated in the same manner. If a feigning hen of the species in question was seen, she was assumed to indicate the presence of the brood provided that she had not flown in from another pothole as often occurred. In spite of its inherent inaccuracies, this residence chart not only provides an index of the population of the pothole at any date, but shows the length of time that any one brood spent there.

For further study of the brood population a chart such as is illustrated in Plate XIb was drawn up. This is merely the breakdown of all the residence charts into the separate species. There was no attempt made here to trace individual broods, and one which was seen in several different potholes may appear several times on the chart. It was usually fairly simple to determine how long a brood remained in one pothole, but impossible in most cases to tell where it went after leaving.

Calculation of Mobility -- By use of the information illustrated in Plate XIb, the average period that broods of a species spent in any one pothole serves as an index to the mobility of the species. Each bar is considered to be one "residence" which consists of a certain number of "brood-days" (the presence of 1 brood for 1 day). The mobility of a species is indicated by the total number of residences divided by the total number of brood days the species spent on the study area; in other words, the reciprocal of the average term of residence.

Table 7 shows the relative mobility of the species found on the study area. Those which furnished less than 10 observations were separated from the rest since it is doubtful whether they have much significance. The shoveller brood using potholes Nos. 29, 30, and 31, whose movements have already been described, was separated from other broods of the species when calculating the mobility rating. The fact that more observations were made on what was known to be one brood than on all of the other shovellers, gave it too much weight. The mobility rating was calculated for this one brood and averaged in with that of other shovellers. The average observed travel from the case histories already described is included in the last column for comparison.

It was impossible in many cases to determine whether a new brood in an area was recently hatched or, on the other hand, whether the departure of a brood indicated that it had walked away or flown off. Since all broods both hatch and fly, those which never moved out of one pothole have their residence terminated at both ends and are given a higher rating than they deserve. Thus the difference between the mobility ratings of the various species is slightly greater than indicated in Table 7.

Table 7. Mobility ratings of the ten species of duck broods on the study area.

| Species | Number of Observations | Mobility rating of all ages | Observed travel (miles per day) |
|---|---|---|---|
| Pintail | 31 | 0.20 | 0.011 |
| Canvasback | 60 | 0.15 | 0.013 |
| Mallard | 53 | 0.14 | 0.013 |
| Redhead | 16 | 0.09 | 0.009 |
| Blue-winged teal | 37 | 0.09 | 0.034 * |
| Baldpate | 15 | 0.05 | 0.001 |
| Ruddy | 10 | 0.03 | 0.002 * |
| Gadwall | 3 | 0.15 | 0.06 * |
| Shoveller | 7 | 0.11 | 0.021 * |
| Green-winged teal | 3 | 0.05 | --- |

* Based on one example only.

It was impossible to determine whether these ratings represent relative ability and willingness to walk overland or relative ease with which birds become dissatisfied with their environment and travel overland to escape it.

## Population Fluctuation as Evidence of Movement

Charts for each species as shown in Plate XIb provide the means for getting a better picture of its population behavior, particularly with regard to movement. With the aid of these charts, the number of brood days spent by the species on the study area can be determined for any period.

Plate XIIa indicates the total seasonal brood population of the area. Since this is based on brood days per 8-day period, dividing by 8 gives the number of brood days per day, or roughly, the number of broods. For example, about 54 broods (439.5/8) were using the area at the peak of the season during the period July 20 to July 28.

There was a rapid increase in population as hatching progressed until the third week in July and a rapid drop at the end of the season when the majority of broods reached flying age.

The changes in abundance of each species through the course of the study varied greatly owing both to the differences in the hatching dates of the various species and to movements of broods onto and away from the area.

A sharp drop occurred in late July in the population of some of the species and in the total population as shown in Plate XIIa, suggesting mass movement away from the area. In order to check this, graphs have been drawn up to show the variations in total population and age composition of broods on the study area. Plate XIIb shows the relative abundance of the species during the entire season.

Nonmobile Broods -- The age composition and population of baldpate and ruddy duck broods (Plate XIII) give an indication of what can be expected when there is neither renesting nor sufficient movement of broods to bring about a marked change in the population. Most individuals of both species hatched their broods during a very short period and there was no indication of renesting on the study area. In both cases, there was little drop in the population once the peak had been reached. Class I broods changed to Class II without showing any losses or gains in abundance.

The blue-winged teal shows a similar situation. There was a sharp drop in early August, but this can be accounted for by the large number of Class III and Class II broods in late July, many of which were flying by August 1. A few late nests are indicated by the presence of Class I broods late in August. This probably can be accounted for by the ability of these ducks to renest as reported by Sowls (1949) who found positive evidence that 2 out of 17 marked hens of this species renested after he had destroyed their nests. Apparently there was no population fluctuation of this species due to movement.

Although there were few broods of the shoveller on the area, data for this species, like the blue-winged teal, indicate low mobility.

Mobile Broods -- Redhead broods were not present in great numbers, but did show some indications of renesting as shown by Class I broods as late as the middle of August. The erratic fluctuations in age ratios indicate that there was considerable movement of broods of this species onto and off the study area.

The canvasback (Plate XII) took a sharp drop of nearly 50 percent from its early July population. Since there were only enough Class III broods present in early July to account for 20 percent of this loss and no flying young were seen until August, it must be assumed that during this period the number of broods which moved off the study area exceeded the number which moved onto it. The lack of Class I broods late in the season, indicating a lack of renesting, may be accounted for by the high success of initial attempts by this species.

In contrast to the loss in canvasback broods, mallard broods showed a 100-percent increase in mid-July. Only 75 percent of this can be attributed to newly hatched broods even when one assumes that all the un-aged birds on the area during the period from July 4 to 12 might have been Class I. The assumption was made that during this period more mallard broods moved onto the study area than away from it.

The pintail had an increase in Class III broods in early July and a loss of Class I's in early August, indicating considerable overland travel.

Too little data were gathered concerning the gadwall or green-winged teal to give much indication of the condition of their population. Both gadwall broods left the study area soon after hatching. The green-winged teal broods stayed within its boundaries, although one had apparently not hatched on the area but had moved onto it in eary July.

Influence of the Size of the Study Area -- Owing to the small number of broods involved and the small size of the study area, chance wanderings were well able to produce the population fluctuations noted. If the population and/or the area had been larger, chance movements onto and off the area should have cancelled each other and no fluctuation would have been apparent.

There was no reason to believe that there was mass migration either onto or off the area. The surrounding terrain had some dry regions which were probably not as attractive to broods as the area itself, but there was no factor discovered which would stimulate general migrations.

These graphs not only indicate that the species which were rated as most mobile in Table 7 showed the greatest population fluctuation due to movement of broods, but also furnish a better picture of the details of these fluctuations.

Although it is impossible to determine accurately the speed and extent of movement from the data at hand, they do suggest that many broods may have traveled farther and more rapidly than any of those which were actually traced. This may also serve to account for the poor success in locating marked broods, since it seems quite possible that they may have left the area before they could be located.

The Three Methods Compared -- The first method, involving a study of marked individuals, presents conclusive data on the details of movement, such as distances moved and number of potholes used. However, it is extremely time-consuming and gives no indication of the percentage of broods which move.

The second method involving the determination of average term of residence gives accurate information on the relative mobility of species and the frequency with which broods moved but none concerning the details of movement. This method is also time-consuming, requiring close coverage of the study area.

The third method, involving census by age classes, is the most easily applied, but furnishes the least conclusive and least detailed information. It does give an indication of the effect of movement on the population of a small area.

Table 7, showing the mobility rating of the pintail as 0.20, indicates that on the average broods of this species used one pothole only 5 days at a time. If, as Hochbaum (1944) reports, the time of development from hatching to flying requires 45 to 58 days, the average pintail brood made use of nine different water areas before flying. The average canvasback, with a mobility rating of 0.15 and requiring 63 to 77 days, uses the same number of potholes. The baldpate, with a mobility rating of 0.05 and requiring 45 to 58 days, would not be expected to use more than two potholes.

## V. POTHOLE PREFERENCE AND FACTORS INFLUENCING MOVEMENT

Some attention was paid to the characteristics of potholes and to the amount of use they received by broods, and it was possible to determine to some extent the relative attractiveness of various pothole types.

On the basis of data on the mobility of species, the assumption is made that within limits broods can and do select those areas which are attractive to them. This ability to select varies with the mobility of the species, but in most cases this may be assumed to be great enough to provide an indication of preferences.

It is difficult to determine what unit of measure is the most valid in determining amount of use. Persons interested in managing areas where the uplands are of little value might wish to consider the number of broods per pothole. On the other hand, one wishing to evaluate the productivity on the basis of land or water area will be interested in broods per acre. So far as the author can determine, each method has its usefulness and where practicable figures will be expressed in broods per pothole and broods per acre.

Size -- Table 8 shows the brood use of all the permanent potholes as influenced by size. The number of broods per pothole rises rapidly until a size of 2.5 to 3.0 acres is reached where it falls off and again rises rapidly as size exceeds 3.5 acres. The largest pothole on the area (10.9 acres) received the heaviest use in terms of broods per pothole but when use is expressed in terms of broods per acre, those areas of 2.5 to 3.0 acres were preferred.

In order to exclude the influence of cover type, the same data are shown for the 25 Type A1 potholes. Here the picture is similar although the greatest amount of use per pothole as well as per acre occurred in the 2.5 to 3.0 acres size class. It may be that if there had been large areas of this type, they would have been used more heavily.

Table 8. The influence of pothole size on use by all broods.

| Pothole size (acres) | All permanent potholes | | | Type A1 potholes | | |
|---|---|---|---|---|---|---|
| | Number of potholes | Brood-days | | Number of potholes | Brood-days | |
| | | Per pothole | Per acre | | Per pothole | Per acre |
| 0.0 - 0.49 | 3 | 0 | 0 | 2 | 0 | 0 |
| 0.5 - 0.99 | 9 | 16.1 | 21.9 | 5 | 19.8 | 27.5 |
| 1.0 - 1.49 | 7 | 23.6 | 18.8 | 4 | 33.7 | 26.5 |
| 1.5 - 1.99 | 8 | 25.1 | 14.5 | 6 | 32.9 | 18.6 |
| 2.0 - 2.49 | 4 | 71.5 | 32.5 | 2 | 88.0 | 40.0 |
| 2.5 - 2.99 | 3 | 95.5 | 36.3 | 2 | 143.3 | 56.2 |
| 3.0 - 3.49 | 2 | 61.0 | 20.0 | 1 | 93.0 | 31.0 |
| 3.5 - 3.99 | 3 | 115.5 | 30.4 | 3 | 115.5 | 30.4 |
| 4.0 and over | 3 | 219.0 | 32.4 | 0 | --- | --- |

Table 9 illustrates the influence of area of open water. Again, there is a peak (in this case in the size class of 2.0 to 2.5 acres) which corresponds to potholes with total areas of 2.5 to 3.0 acres, but the 0.0 to 0.5 acre potholes (corresponding roughly to potholes with total areas of 0.0 to 0.99 acre) received almost as much use per acre as the larger waters. This is more nearly in agreement with the finding of Furniss (1935, 1938) who reports that in northern Saskatchewan the greatest use per acre was of potholes 0.0 to 0.5 acre in size.

It was impossible to draw similar graphs for any of the other pothole types, since they did not occur in sufficient numbers.

Table 10. -- The Influence of Size of Type A 1 Potholes on Use by Broods

| Species | Pothole Size (Acres) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.0 to 0.49 (2)* | 0.5 to 0.99 (5) | 1.0 to 1.49 (4) | 1.5 to 1.99 (6) | 2.0 to 2.49 (2) | 2.5 to 2.99 (2) | 3.0 to 3.49 (1) | 3.5 to 3.99 (3) |
| Mallard | | | | | | | | |
| Brood-days per pothole | 0 | 12.0 | 3.0 | 10.7 | 7.0 | 20.8 | 9.5 | 11.3 |
| Brood-days per acre | 0 | 16.7 | 2.4 | 6.0 | 3.2 | 8.1 | 3.2 | 3.0 |
| Pintail | | | | | | | | |
| Brood-days per pothole | 0 | 1.6 | 6.4 | 1.8 | 11.0 | 4.5 | 3.0 | 12.0 |
| Brood-days per acre | 0 | 2.2 | 5.0 | 1.0 | 5.0 | 1.8 | 1.0 | 3.2 |
| Blue-winged teal | | | | | | | | |
| Brood-days per pothole | 0 | 0.0 | 4.6 | 13.0 | 17.5 | 17.0 | 30.0 | 7.0 |
| Brood-days per acre | 0 | 0.0 | 3.6 | 7.4 | 8.0 | 6.7 | 10.0 | 1.8 |
| Baldpate | | | | | | | | |
| Brood-days per pothole | 0 | 4.0 | 13.3 | 1.3 | 5.5 | 22.5 | 12.0 | 30.7 |
| Brood-days per acre | 0 | 5.6 | 10.6 | 0.8 | 2.5 | 8.8 | 4.0 | 8.1 |
| Redhead | | | | | | | | |
| Brood-days per pothole | 0 | 0.6 | 0.0 | 0.5 | 4.0 | 32.0 | 11.0 | 12.5 |
| Brood-days per acre | 0 | 0.8 | 0.0 | 0.3 | 1.8 | 12.6 | 3.7 | 3.3 |
| Canvasback | | | | | | | | |
| Brood-days per pothole | 0 | 2.0 | 2.8 | 2.3 | 31.0 | 25.3 | 27.5 | 21.2 |
| Brood-days per acre | 0 | 2.8 | 2.2 | 1.3 | 14.1 | 9.9 | 9.2 | 5.0 |

* Number in parentheses indicates number of potholes.

Table 9. The influence of area of open water on use by all broods

| Area of open water (acres) | All permanment potholes | | | Type A1 potholes | | |
|---|---|---|---|---|---|---|
| | Number of potholes | Brood-days Per pothole | Brood-days Per acre | Number of potholes | Brood-days Per pothole | Brood-days Per acre |
| 0.0 - 0.49 | 12 | 9.9 | 47.4 | 6 | 11.0 | 60.0 |
| 0.5 - 0.99 | 11 | 27.5 | 43.1 | 5 | 34.8 | 58.0 |
| 1.0 - 1.49 | 6 | 58.5 | 49.7 | 5 | 38.6 | 33.3 |
| 1.5 - 1.99 | 6 | 64.0 | 38.8 | 4 | 68.5 | 41.5 |
| 2.0 - 2.49 | 2 | 140.0 | 65.1 | 2 | 140.0 | 65.1 |
| 2.5 - 2.99 | 3 | 91.8 | 49.2 | 2 | 123.3 | 43.9 |
| 3.0 - 3.49 | 1 | 100.0 | 31.3 | 1 | 100.0 | 31.3 |
| 3.5 - 3.99 | 0 | --- | --- | 0 | --- | --- |
| 4.0 and over | 1 | 395.0 | 42.0 | 0 | --- | --- |

There was considerable variation in the preference for pothole size shown by the various species of ducks. Table 10, showing the species use of the 25 Type A1 areas, indicates that the mallard prefers small areas while the canvasback and redhead use larger potholes. The blue-winged teal, baldpate, and pintail are more variable in size preference. Similar data relating to area of open water show a similar picture. However, the mallard and strangely enough the canvasback were the only species known to use potholes with 0.0 to 0.49 acre of open water.

Cover Type -- Although there were too few potholes for comparisons to be made between different cover types in one size class, data based on all the potholes give the information shown in Table 11 relating to the use made of each of the cover types. Type A1 received the greatest use, 1,332 brood-days, or 59.5 percent of the total; Type A3 was next in use, 687 brood-days, or 30.8 percent of the total. There was no use by broods of B2, B3, B4, or D potholes. The heavy use of A1 areas is probably due in part to the greater total acreage of this type.

As shown in the second column, Type A3 received heaviest use per pothole, probably owing to the large average size of these areas. The last column attempts to compensate for the variations in size by showing the use per acre of each type. (Acreage is figured on the basis of the entire pothole including marginal vegetation.) A1 (30.4 brood-days per acre) is the preferred type, closely followed by A3 (29.4 brood-days per acre), with A2 and A4 receiving a relatively small amount of use and the semipermanent and temporaries almost none.

Table 11. Brood use of the 10 cover types.

| Pothole type | Total brood-days in type | Brood-days per pothole | Brood-days per acre |
|---|---|---|---|
| A1 | 1,332.0 | 53.3 | 30.4 |
| A2 | 165.0 | 27.5 | 19.4 |
| A3 | 687.0 | 171.8 | 29.4 |
| A4 | 31.5 | 4.5 | 3.6 |
| B1 | 19.0 | 0.5 | 1.1 |
| B2 | None | None | None |
| B3 | None | None | None |
| B4 | None | None | None |
| C | 1.5 | 0.1 | 0.2 |
| D | None | None | None |

Table 12 shows the preferences of the various species present in terms of percent acreage use (the percent of all use which occurred in the type divided by the percent of the pothole acreage made up of the type).

Table 12. Percent acreage-use value for the 10 pothole types as determined by brood occupancy (calculated).

$$\text{Percent acreage-use} = \frac{\text{Percent use of type}}{\text{Percent acreage of type}}$$

| | Pothole type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A1 | A2 | A3 | A4 | B1 | B2 | B3 | B4 | C | D |
| All broods | 1.6 | 1.0 | 1.5 | 0.2 | 0.1 | -- | -- | -- | trace | -- |
| Baldpate | 2.3 | 1.7 | -- | -- | -- | -- | -- | -- | -- | -- |
| Blue-winged teal | 1.4 | 0.6 | 2.2 | 0.1 | -- | -- | -- | -- | -- | -- |
| Canvasback | 1.7 | 0.7 | 1.5 | -- | 0.1 | -- | --- | -- | -- | -- |
| Gadwall | 0.1 | -- | 3.9 | 2.3 | -- | -- | -- | -- | -- | -- |
| Green-winged teal | 1.8 | -- | 1.6 | -- | -- | -- | -- | -- | -- | -- |
| Mallard | 1.8 | 1.1 | 0.9 | 0.8 | 0.1 | -- | -- | -- | trace | -- |
| Pintail | 2.3 | -- | 0.2 | 0.1 | 0.5 | -- | -- | -- | -- | -- |
| Redhead | 2.2 | -- | 0.8 | -- | -- | -- | -- | -- | -- | -- |
| Ruddy | 0.6 | 0.2 | 3.8 | -- | -- | -- | -- | -- | -- | -- |
| Shoveller | 0.5 | 8.2 | 0.7 | 0.5 | -- | -- | -- | -- | -- | -- |

The mallard was apparently the most adaptable species, as it was the only one found in temporary waters and it made more use of A4 potholes than did others. The baldpate and ruddy were apparently the least tolerant. The relatively heavy use of Type A2 by baldpates all occurred in pothole No. 39, which is on the borderline between Type A1 and Type A2, indicating that this species was fairly dependent on the former. The ruddy, on the other hand, was apparently dependent on the hardstem-bulrush areas. This may have been due to its low mobility which made it unlikely that broods of the species would leave the potholes which were preferred as nesting cover. Blue-winged teal and canvasback broods appeared fairly tolerant to varying conditions, but still showed preference for Types A1 and A3. Both redhead and pintail showed definite preference for Type A1, the former species appearing to be the more adaptable as it made some use of A4 and B1 areas. The preference of the shoveller for Type A2 was quite clear-cut, since very little of the time spent in this type was in areas resembling A1 potholes as occurred in the baldpate. Data on the green-winged teal and gadwall are included but are undoubtedly of very little significance owing to the small number of broods of these species using the area.

Rainfall -- By means of the data in Plate XIb it was possible to calculate the daily fluctuations in mobility of one species. Each day's mobility may be calculated as the number of terminations of residence divided by the number of broods involved. Since this furnished a very scattered graph, it was smoothed out by using a moving average of three consecutive daily readings of the data from Plate XIb.

The daily fluctuations in mobility of the canvasback are shown in Plate XV. The only period for which these data are valid is that during which there were few broods newly hatched and few flying. Since broods were aged in only three classes it was impossible to determine the status of individual broods in this respect. However, Plate XIV shows that during the period from July 2 to August 1, the age composition of the population was relatively stable and there was a minimum of five broods each day so that data for this period should be significant. Two definite peaks in mobility occurred during this period. These peaks may be offset to some extent by error in calculating the exact day a brood moved into or deserted an area and they are somewhat spread by the moving average, but they indicate a definite increase of movement on or about these dates.

The possible significance of these periods of high mobility may be seen when they are compared with the dates of the two heavy rains which occurred during July,

the first of 1.5 inches starting on July 19 and the second of 2.9 inches starting on July 27. They indicate that movement of canvasback broods may be stimulated either by high water or by rising water levels.

This method of analysis could not be used for other species since either there were too many broods hatching or flying during the critical period or there were too few broods present.

Effect of Depth and Season -- Since the depths of potholes were variable and the use of different areas was seen to vary with the season, four of the more mobile species, two diving ducks (redhead and canvasback) and two river ducks (mallard and pintail), were considered with regard to their depth preferences. Owing to their high mobility, these species were able to respond most easily to changing conditions.

Plate XVI shows the use made of water areas of several types in two depth classes. The measurements were made in mid-August and are considered sufficiently accurate for such a comparison. It can be seen at a glance that the diving ducks made more use of the deeper areas than did the river ducks.

Mose of the use of A3 areas by diving ducks occurred early in the season. This may be due in part to their abundance of submerged aquatics which later developed to such an extent that they made diving difficult. Both groups of broods showed a slight drop in the use of shallow areas during the dry periods of mid-July and late summer, and an increase in their use during the high water from July 19 to early August. It should be remembered that, as in the data shown in Plate XV, there is room for an error of 2 or 3 days in estimating the times when these broods were in each pothole, which might obscure rapid shifts in use. The rise in use of deep areas by mallard and pintail broods may actually have continued until July 19 and there may have been an increase in use of shallow areas starting on that date. The decline in the use of deep areas by redhead and canvasback broods may also have occurred as a result of the rain on July 19. This serves to indicate that there was very probably some shifting of the general population due to falling water levels as was found to occur in pothole No. 33 where a daily count of the broods present (Plate XVII) shows a steady drop from 10 broods to 3 during the period when water levels were falling (July 8 to July 19). During this time the water was receding from the shore cover so that broods could no longer swim freely through the vegetation. At the same time the pothole became quite shallow (18 inches at the deepest point) so that broods could not easily escape by diving. Both of these conditions, which did not occur to such a marked degree on any other pothole, may well have made them nervous and encouraged movement away from the pothole.

Broods apparently react to unfavorable conditions be deserting an areas, and may reoccupy it when conditions again become favorable as they did in this instance.

Abundance of Potholes -- A glance at the map of the study area (Plate III) shows that roughly its northern third has fewer potholes than the remaining two-thirds. The effect of this difference is shown in Table 13, which is based on permanent waters only.

Table 13. Effect of abundance of potholes on use by broods and mobility of broods.

| | Northern 1/3 | Middle 1/3 | Southern 1/3 |
|---|---|---|---|
| Number of potholes | 11 | 17 | 18 |
| Brood-days of use | 756.0 | 501.5 | 957.0 |
| Brood-days of use/Acre of pothole | 26.3 | 22.8 | 26.7 |
| Mobility of broods | 7.6 | 15.4 | 12.8 |

The total brood-days of use of the northern third with the fewest potholes was intermediate between the other two sections, and there was apparently no significant difference in the use per acre of pothole between the three regions, indicating that if pothole density is important, those in this particular area were all so closely spaced that it did not take effect. The influence of the spacing of potholes on brood mobility is quite marked. Those which occupied the region of high density were nearly twice as mobile as those in the northern third. It appears probable that the ease of access of more nearly adjacent potholes in the southern two-thirds might encourage movements. In support of this, it should be stated that the most mobile brood observed was the shoveller brood occupying potholes Nos. 29 and 31 which are separated by only a narrow strip of land.

Food -- Although lack of time and facilities prevented a study of the availability or utilization of food, it seemed probable from a casual inspection of potholes that food, principally invertebrates, was of such abundance as not to be a critical item.

Two cases of rapid increase in the brood population of areas previously untenanted may have been the result of a change in the abundance of food sufficient to attract broods. The first was pothole No. 10, used only for 8 days from July 23 to 31 when it was occupied by six broods for an average of 4 days each. This may have been due either to a temporarily attractive food supply or to a chance concentration of broods which had increased mobility during this period of high water. The second case was pothole No. 35, which had no broods until July 12, when one came in. By July 13 there were six, and it was then occupied by from four to seven broods until the termination of the study, when six broods remained.

Benson (1948) made a detailed study of the available food in a comparable area and concluded that it was so abundant that it was not an important factor in the selection of water areas.

Occupancy by Other Broods -- This is a difficult factor to evaluate. Such data as were obtained indicate that no density limit was reached on the study area.

The cases shown in Table 14 indicate the extent to which broods were known to associate in one pothole. These cases are well above the average concentration found on the study area and indicate that the population had not reached its density limit from the standpoint of broods, particularly since there was no conflict observed which might have been attributed to high densities. The mobility of these birds was calculated in the same way as the average mobility for the species. In only seven cases were closely packed birds more mobile than the average for the species. Apparently, the potholes in which the broods concentrated were more attractive than the average, and broods spent longer periods of time in them. All species but the ruddy had their greatest concentration in broods per acre in Type A1 potholes.

Use by Other Species -- Coots, horned and pied-billed grebes, and black terns were seen to occupy the same potholes as duck broods and at times appeared to be in conflict with them. Apparently there was no decrease in the use of potholes by ducks because of interference from these other species. The over-all average use of the 42 permanent potholes was 22.0 brood-days per acre of pothole. The 17 potholes with no coots averaged 10.2 brood-days per acre while the 25 which had coots average 30.0. The 29 potholes without grebes averaged 20.2 brood-days per acre while the 13 with grebes averaged 25.9. The 39 potholes without black terns averaged 19.8 brood-days per acre while the three with black terns averaged 50.4.

The only mortality apparently caused by these species was in pothole No. 1 where several coots, both young and adult, and one half-grown mallard had been killed,

apparently by black terns which had a nesting colony on the area and defended it against all comers. These birds had all suffered cuts and bruises on the backs of the head and neck. In spite of this, the area was heavily used by all found species mentioned. Suitability in other respects apparently outweighed the disadvantages of possibly competing species. These results are similar to those of Munro (1939) who concluded that loons, holboell's grebes, and coots were not a major factor influencing the use of water areas by ducks.

Table 14. Maximum known concentrations of broods on the study area.

| Broods in pothole | Pothole number | Pothole size (Acres) | Broods per acre |
|---|---|---|---|
| Groups of a single species | | | |
| 3 mallard | 1 | 10.9 | 0.3 |
| 2 mallard | 17 | 1.8 | 1.1 |
| 2 mallard | 15 | 1.2 | 1.7 |
| 2 mallard | 7 | 0.8 | 2.5 |
| 2 pintail | 41 | 2.1 | 1.0 |
| 4 pintail | 33 | 3.9 | 1.0 |
| 4 blue-winged teal | 1 | 10.9 | 0.4 |
| 2 blue-winged teal | 24 | 1.9 | 1.1 |
| 2 baldpate | 33 | 3.9 | 0.5 |
| 3 redhead | 35 | 2.6 | 1.2 |
| 5 canvasback | 1 | 10.9 | 0.5 |
| 3 canvasback | 33 | 3.9 | 0.8 |
| 2 canvasback | 21 | 2.5 | 0.8 |
| 3 canvasback | 22 | 3.0 | 1.0 |
| 2 canvasback | 24 | 1.9 | 1.1 |
| 3 canbasback | 40 | 2.3 | 1.3 |
| 4 ruddy | 1 | 10.9 | 0.4 |
| 2 ruddy | 5 | 5.0 | 0.4 |
| Groups of all species | | | |
| 1 mallard, 1 green-winged teal, 4 blue-winged teal, 1 shoveller, 1 canvasback, 4 ruddy | 1 | 10.9 | 1.1 |
| 1 blue-winged teal, 1 baldpate, 3 redhead, 1 canvasback, 1 ruddy | 35 | 2.6 | 2.7 |
| 1 mallard, 1 pintail, 1 blue-winged teal, 1 baldpate, 1 shoveller | 20 | 1.6 | 3.1 |
| 1 mallard, 1 pintail, 1 blue-winged teal, 1 baldpate, 1 canvasback | 10 | 1.4 | 3.6 |

Human Intrusion -- Disturbance was generally kept at a minimum throughout the study, and the influence of disturbance on the movements of broods could not be accurately evaluated. Several examples may shed some light on the question. On July 14, 2 hours were spent with the aid of an assistant in attempting to capture a marked redhead brood on pothole No. 35. This was done by driving them into the narrow end in order to capture them by hand. This brood was not driven out and remained in the pothole until August 13 in spite of the disturbance. There were five other broods in the pothole at the time, one each of redhead, mallard, canvasback, pintail, and blue-winged teal. The mallard and redhead broods remained until July 21, but the other three were not seen again. Whether the disturbance was the primary cause of the departure of the latter is not known.

As described earlier, the movements of one shoveller brood on pothole No. 31 were undoubtedly influenced by the activity about the camp. This did not prevent the brood from returning once the activity had ceased.

A canvasback brood which spent 2 days in this same area showed considerable alarm at times of human activity and finally departed during the time that two visitors went swimming in the pothole.

In August a wire drive trap was used on pothole No. 36 in an attempt to catch a brood of baldpates. This was done by placing the "V" type trap across the shore line with one wing extending out into the water and one up on shore. Repeated attempts were made to drive the birds around the pothole through the marginal vegetation and into the trap. This entailed a maximum amount of disturbance in the form of beating the vegetation and shouting which lasted about 30 minutes on each trial. The first drive was made August 9, when the baldpates and a ruddy-duck brood were present. On August 16, while the baldpate, a ruddy, and a redhead brood were present, two drives were made and the trap was left in position. On the evening of August 17 another drive was made and the trap was removed. The same three broods were later observed at the pothole indicating that it may be difficult to drive broods of at least these species from an area that is otherwise suitable.

Age of Broods -- Table 15 shows the mobility of Class I and early Class II separated from the later Class II and Class III broods. Only those species are included for which there are at least six observations in each age group. Seven motherless broods which appeared to become immobile after the departure of the hen are excluded from the calculations.

The mallard was the only species for which mobility decreased with age, while the average increase in mobility with age was 23.7 percent. It should be mentioned here that the data showing the relation of movement to water levels shown in Plate XV were apparently not affected by the ages of the broods involved since both age groups were approximately equally represented.

Table 15. Effect of age on brood mortality.

| Species | Mobility | | |
|---|---|---|---|
| | All ages | Class I and early Class II | Late Class II and Class III |
| Canvasback | 14.5 | 13.9 | 16.9 |
| Mallard | 13.6 | 15.2 | 13.0 |
| Blue-winged teal | 8.6 | 7.5 | 10.8 |
| Pintail | 19.6 | 15.8 | 24.0 |
| Average | 14.1 | 13.1 | 16.2 |

Mobility of Motherless Broods -- The desertion of broods by the females apparently had some bearing on their mobility since no motherless broods were known to move overland. Apparently most overland travel took place when the hens were present and perhaps was initiated by them.

No deserted broods were found in shallow areas which showed signs of drying up. This may have been due either to efforts on the part of the hens to leave their young in suitable habitat or to chance, since the unstable areas received little use by any broods at the time most hens were leaving the area.

## VI. RATE OF MORTALITY AND DISPERSION OF BROODS

### Mortality

Observed Losses -- Since recognizable broods were observed over a period of time there is some information available on the actual rate of loss of young. This is summarized in Table 16. The number of young observed (column 2) are those counted when the broods were first observed.

The mobility of the broods from which these data were obtained were compared with the over-all mobility of broods as already discussed and was found to be the same.

Table 16. Known losses from recognizable broods.

| Species | Number of broods | Number of young | Average days observed | Young lost |
|---|---|---|---|---|
| Canvasback | 11 | 63 | 21 | 0 |
| Baldpate | 6 | 46 | 31 | 6 |
| Redhead | 3 | 21 | 32 | 6 |
| Mallard | 3 | 16 | 17 | 0 |
| Pintail | 2 | 13 | 28 | 1 |
| Ruddy | 2 | 17 | 34 | 2 |
| Blue-winged teal | 1 | 10 | 4 | 1 |
| Shoveller | 1 | 10 | 34 | 2 |
| Gadwall | 1 | 11 | 11 | 2 |
| Total | 30 | 207 | 25 | 20 |

It should be noted that there were no losses of canvasback or mallard, which together made up a large portion of the observations, while all but 2 of the 20 young which were lost were Class I birds indicating that losses decreased as the broods increased in age.

Five nonmobile broods with 35 young were observed for an average of 27 days. When these broods were compared with 17 mobile broods of the same species which had 107 young observed for an average of 27 days, the rate of loss of the former was found to be slightly greater than the latter. This is too small a sample to be highly significant but indications are that the broods which move overland may suffer less mortality than those which remain stationary and that possibly some movement may be to escape predation.

Change in Average Brood Size -- Another way of measuring juvenile mortality is by means of comparing average brood sizes in the various age classes. Numerous authors gathered such data on the Canadian breeding grounds this same season. As reported in Williams (1949) table 17 shows the sizes of those broods for which good counts were obtained in the Minnedosa study. (Duplicate counts were eliminated wherever possible.) When each species was considered individually, there was an apparent increase in the sizes of broods as they became older.

One explanation for this might be the combination of broods, or hens gathering up young abandoned by other broods, but no indication was seen that either of these events took place. A more likely explanation is that first clutches, as reported by Sowls (1949), are significantly larger than those of later nesting attempts. The broods recorded as Class III during the term of the study were largely the products of these earlier clutches and may have been larger than broods hatched later which were recorded largely in the younger classes. Although the average size of all Class III broods is somewhat smaller than Class I, the difference in

the species making up these totals influences the results. It should be pointed out that there were no data gathered on mortality of young before they reached their first water area, as this would have required an intensive nesting study.

Table 17. Average brood sizes by age class.

| Species | Class I | | Class II | | Class III | | Average of all ages | |
|---|---|---|---|---|---|---|---|---|
| | Number of broods | Brood size | Number of broods | Brood size | Number of broods | Brood size | Number of broods | Brood size |
| Baldpate | 15 | 6.4 | 4 | 5.0 | 1 | 6.0 | 20 | 6.1 |
| Blue-winged teal | 36 | 7.8 | 15 | 7.9 | 8 | 8.6 | 59 | 8.0 |
| Canvasback | 31 | 5.5 | 36 | 5.6 | 14 | 5.4 | 81 | 5.6 |
| Gadwall | 5 | 8.6 | -- | -- | -- | -- | 5 | 8.6 |
| Green-winged teal | 2 | 6.5 | 2 | 7.5 | 1 | 5.0 | 5 | 6.6 |
| Mallard | 7 | 5.7 | 7 | 5.9 | 10 | 6.6 | 24 | 6.3 |
| Pintail | 4 | 3.8 | 6 | 8.2 | 6 | 5.0 | 16 | 5.9 |
| Redhead | 27 | 6.1 | 7 | 6.4 | -- | -- | 34 | 6.2 |
| Ruddy | 9 | 7.2 | 5 | 7.8 | -- | -- | 14 | 7.4 |
| Shoveller | 4 | 8.0 | 8 | 7.8 | 3 | 6.0 | 15 | 7.5 |
| Total | 140 | 6.6 | 90 | 6.6 | 43 | 6.3 | 273 | 6.5 |

(Percent difference between Class I and Class III = 4.7%)

Possible Decimating Factors - Only two young ducks were found dead during the course of the study. The young mallard found in pothole No. 1 with lacerations on the head and neck may well have been killed by black terns. The marked mallard found near the nest was probably killed by thirteen-lined ground squirrels.

Other predators present were at least one horned owl (Bubo virginianus), one feral house cat (Felis domesticus), several red foxes (Vulpes fulva), numerous marsh hawks (Circus cyaneus), a pair of Swainson's hawks (Buteo swainsoni), a pair of red-tailed hawks (Buteo jamaicensis), and a few mink. None of these species was observed attacking ducklings.

## Dispersion of Broods

Age at Dispersal -- The age at which broods became scattered varied considerably with the species and depended to some extent on the constancy of the mothers. River-duck hens were judged more "faithful" mothers than the diving ducks as only 19 percent of the river-duck broods were seen without hens, while 23 percent of canvasback and redhead broods and 39 percent of ruddy broods seen were motherless.

The following table, showing the percentage of motherless broods in the three age classes, indicates that diving-duck and ruddy-duck hens desert their broods at an earlier age than do river-duck hens.

Table 18. Percent of broods without hens.

| Age class | River ducks | Diving ducks | Ruddy ducks |
|---|---|---|---|
| I | 6% | 9% | 13% |
| II | 14% | 23% | 57% |
| III | 42% | 64% | 100% |

One mallard brood which was observed repeatedly was accompanied by the hen 14 days after the first of the young were seen to fly. This hen was still feigning injury even though the brood was well able to escape. A green-winged teal hen also was seen accompanying a group of flying young presumed to be her brood since one of a corresponding age and number had been repeatedly observed on pothole No. 33. No broods of diving ducks or ruddy ducks were seen accompanied by hens after they appeared ready to fly.

Most broods appeared to remain as units from the time they were deserted by their hens until they were ready to fly, very few young having been observed as singles. Desertion by the hen was apparently only the first stage of brood dispersal which was usually not complete until after the young had flown.

Age of Attainment of Flight -- Since three broods were observed from the time of hatching until they were judged ready to fly, it was possible to gain some information on rate of growth in the wild.

A canvasback brood hatched June 30 reached Class II on July 25 at the age of 26 days. By August 14, at the age of 46 days, it was Class III, and by August 22, at the age of 54 days, the primaries were almost fully grown and it was judged ready to fly.

A redhead brood hatched July 2 reached Class II on July 30 at the age of 28 days, and Class III on August 20 at the age of 49 days; on August 27, when it was 56 days old, it was judged ready to fly.

A baldpate brood hatched July 5 reached Class II on July 28 at the age of 23 days. It was not clear when it became Class III, but it was judged to have reached flying age by August 21 at the age of 47 days.

From these data, it appears that birds in the wild may require less time to reach flying age than do birds in captivity as indicated by Hochbaum (1944), who found that canvasback require 63 to 77 days, redhead 63 to 77, and baldpate 45 to 58.

## VII. PRODUCTIVITY OF THE AREA

Count of Breeding Pairs -- Since the count of breeding adults was made late in the season, it was necessary to tally all of the following categories as pairs: (1) Observed pairs, (2) lone drakes, (3) lone females (presumed to be incubating females absent from their nests), and (4) brood hens. Care was taken to avoid duplicate counts by eliminating any birds which had apparently been already counted when flushed from a previously censused pothole.

Calculation of Broods Produced -- The basis for calculating brood production was a count made during the period July 13 to July 17 with the aid of E. F. Bossenmaier. Excellent weather prevailed during this period and it was felt that most broods were seen. Added to this count were two mallard and two pintail broods seen during the first run (June 12 to June 18) which were old enough to be flying by the later date. Three baldpate, four teal, one mallard, two redhead, and four ruddy-duck broods hatched after July 17 were also added. The total represented the sum of three instantaneous counts and was not the sum of all broods seen. Because of movements as discussed previously, the latter figure would represent all broods which had been seen visiting the area. The numbers of breeding pairs and broods reduced to a square-mile basis are shown in Table 19.

Table 19. Productivity of the study area.

| Species | Pairs/Square mile | Broods/Square mile | Ratio: Broods/Pair |
|---|---|---|---|
| Mallard | 30.4 | 9.3 | 0.3 |
| Canvasback | 10.8 | 7.3 | 0.7 |
| Blue-winged teal | 17.7 | 6.6 | 0.4 |
| Baldpate | 5.4 | 5.3 | 1.0 |
| Ruddy | 5.4 | 5.3 | 1.0 |
| Redhead | 5.4 | 4.7 | 0.9 |
| Pintail | 5.4 | 4.0 | 0.7 |
| Shoveller | 3.8 | 1.3 | 0.3 |
| Green-winged teal | 1.5 | 1.3 | 0.9 |
| Gadwall | 2.3 | 0.7 | 0.3 |
| Unidentified teal | --- | 3.3 | --- |
| Unidentifed | --- | 0.7 | --- |
| Totals | 88.1 | 49.8 | 0.56 |

There were sufficient data for the mallard and blue-winged teal to indicate that productivity of these species was low. Nesting data on 52 nests also showed poor success of individual nesting attempts. The canvasback not only produced 70 broods per 100 pairs but also had a high nest success (80 percent). As previously discussed, there appeared to be no renesting in this species. The data indicate that under such conditions as were found at Minnedosa, 88 breeding pairs per square mile raised 50 broods. A weighted-average Class III brood size of 6.3 (Table 17) indicates that 315 young per square mile were produced in this region. This is similar to data obtained by Lynch (in Williams 1949) who found that in 43 Saskatchewan potholes 364 pairs produced 193 broods (53 percent).

A glance at the population curves of the broods of the various species (Plates XIII and XIV) serves to point out the possible inaccuracy of the data gained on the study area, which was apparently too small. The effect of movement on and off the area was quite marked. This effect would have been decreased on a larger area where the ratio of circumference to areas and therefore the effect of influxs would have been less.

A better measure of production might have been obtained by dividing the total number of brood-days each species spent in the area by the average period of preflight development for the species. However, the study was not carried out in 1949 for a sufficient length of time to cover the entire span of the brood season. Moreover, there are not sufficient data on the growth rate of wild birds to accurately determine how long a period should be used to indicate the period of brood development.

## VIII. POTHOLE PREFERENCES OF BREEDING ADULTS AND FLYING YOUNG

### Use of Potholes by Breeding Pairs

Cover Type Preference -- During the first count of breeding pairs and search for nests from June 13 to June 18, notes were made on the locations where breeding adults were found. Plate XVIII shows the use made of the various types by 91 breeding pairs during this period. (Broods and incubating hens were not included.)

All but three types, A2, B3, and B4, were used extensively, types A4 and D most heavily by dabblers, while diving ducks were found exclusively in Types A1 and A3. The lack of use of Types B3 and B4 is probably not significant since no potholes of the former and only two of the latter types were sampled. The others were either dry or outside the boundaries of the area as it was first established. The low use of Type A2 suggests that the dense cattail surrounding these areas may have restricted visibility to the extent that birds did not feel secure in them.

Table 20 shows the percentage of potholes occupied by breeding pairs during this period. Types A3 and D were the most heavily used (100 percent of each occupied) while Types A1 and A4 follow with 78 percent and 71 percent.

Table 20. Percent occupancy by type (breeding pairs).

| Type | Number of potholes sampled | Percent occupied |
|---|---|---|
| A1 | 18 | 78 |
| A2 | 5 | 20 |
| A3 | 3 | 100 |
| A4 | 7 | 71 |
| B1 | 26 | 42 |
| B2 | 5 | 40 |
| B3 | 0 | 0 |
| B4 | 2 | 0 |
| C | 6 | 67 |
| D | 3 | 100 |
| Total | 75 | 57 |

Size Preference -- Table 21 shows the size of potholes used most heavily by breeding birds. In order to rule out the effects of cover types, only the Type A1 and B1 potholes were considered.

Table 21. Influence of pothole size on use by breeding pairs (44 Types A1 and B1 potholes).

| Pothole size (acres) | Number of potholes | Pairs per acre | |
|---|---|---|---|
| | | River ducks | Diving ducks |
| 0.0 - 0.49 | 15 | 2.9 | 0 |
| 0.5 - 0.99 | 12 | 1.1 | 0 |
| 1.0 - 1.49 | 6 | 1.5 | 0 |
| 1.5 - 1.99 | 5 | 0.9 | 0 |
| 2.0 - 2.99 | 3 | 0.3 | 0.4 |
| 3.0 - 3.99 | 3 | 0.6 | 0.4 |

Dabbling ducks in terms of pairs per acre of pothole made the greatest use of the 0.0 to 0.5 acre areas, while the diving duck curve starts at the 2 to 3 acre size class. There is a decrease in intensity of use by breeding river ducks with increase in size of the area. This phenomenon has already been discussed by Stoudt (in Williams 1949) and by Hochbaum (1944) who has shown that the number of pairs occupying an area is dependent upon the length of shoreline, which increases only as the square root of the area.

The heavy use of Type A3 by diving ducks (Plate XVIII) may be caused more by the large size of those areas than by their cover type; comparison of Plate XVIII and Table 21 with Tables 8 and 11, showing the use made of the pothole types by broods, shows that the breeding birds were affected more by the size of the area and less by its cover type than were broods.

## Distribution of Nests

Diving Ducks -- All of the 27 diving-duck nests found on the area were in the emergent vegetation of potholes. Table 22 shows the use and percent acreage use value of each pothole type for these nests. Although most of the nests were in Type A3, four were in Type B2 and six in Type A2. Neither of these latter types was known to be used by breeding pairs of diving ducks and they were very little used by broods. Although no broods were seen in B2 areas, two marked broods were hatched in potholes of this type and both were seen in other areas, one on the day after hatching. These data indicate that these species may nest on areas used neither for territory nor brood rearing.

River Ducks -- Since, with the exception of one mallard nest found in the white top margin of an A1 pothole, the 24 known nests of river ducks found were on the uplands, it was impossible to assign any of them to individual potholes. They were apparently randomly scattered and usually lay at some distance from water, often as far away as possible.

Two blue-winged teal nests found adjacent to pothole No. 31 furnished some information. This pothole was under observation several times each day owing to its proximity to the camp, which overlooked it. At no time were adult blue-winged teal or broods seen on this pothole except when feigning injury after being flushed from the nest. One of these hens was observed twice after leaving the nest on her own volition. She flew directly from the nest, not resting on the pothole, and continued southeastward until out of range of 10-power binoculars (1/2 to 3/4 mile).

Table 22. Use of potholes for diving-duck nests.

| Pothole type | Species | | | Total |
|---|---|---|---|---|
| | Canvasback | Redhead | Ruddy | |
| A1 | | | | |
| Number of nests | 1 | -- | -- | 1 |
| % Acreage-use | 0.3 | | | 0.1 |
| A2 | | | | |
| Number of nests | -- | 3 | 3 | 6 |
| % Acreage-use | -- | 4.6 | 5.1 | 3.0 |
| A3 | | | | |
| Number of nests | 5 | 1 | 5 | 11 |
| % Acreage-use | 2.5 | 0.6 | 3.1 | 2.0 |
| A4 | | | | |
| Number of nests | -- | 2 | -- | 2 |
| % Acreage-use | -- | 2.9 | -- | 1.0 |
| B1 | | | | |
| Number of nests | 1 | 2 | -- | 3 |
| % Acreage-use | 0.7 | 1.6 | -- | 0.8 |
| B2 | | | | |
| Number of nests | 3 | 1 | -- | 4 |
| % Acreage-use | 9.4 | 3.5 | -- | 4.6 |

Note--No nests found in Types B3, B4, C, or D.

The assumption was made that in both cases the waters used for nesting and feeding were not adjacent to the nests, and in one case it was probably at a considerable distance.

The data furnished by both diving ducks and river ducks indicate that the nesting site often bears no relation to the potholes used by the breeding birds for other activities nor to potholes used for brood rearing.

Use of Water Areas by Flying Young

Table 23 shows the dates on which young of the various species were first seen to fly and on which they were most abundant, and includes a very rough estimate of their abundance at this peak.

Table 23. Dates of appearance of flying young.

| Species | First seen | Peak | Approximate number at peak |
|---|---|---|---|
| Pintail | 7/14 | 7/24 - 7/30 | 30 |
| Mallard | 7/14 | 8/14 - 8/20 | 60 |
| Blue-winged teal | 7/23 | 8/21 - 8/29 | 140 |
| Canvasback | 8/1 | 8/14 - 8/20 | 35 |
| Green-winged teal | 8/8 | 8/21 - 8/29 | 9 |
| Shoveller | 8/14 | 8/14 - 8/20 | 2 |
| Redhead | 8/14 | 8/14 - 8/20 | 2 |
| Baldpate | None seen flying | | |
| Ruddy | None seen flying | | |
| Gadwall | None seen flying | | |

These birds were extremely mobile and there was no possibility of determining the extent of their movements. They appeared to have no fixed base of operations and groups were rarely seen twice in the same place. The one exception was a group of 29 young canvasbacks which occupied pothole No. 34 from August 14 to 20. There were only about six other flying young of this species seen elsewhere on the area. Oddly enough, this was the only pothole on which diving-duck hens were seen to gather. Eight canvasback and two redhead hens were seen repeatedly on this pothole from June 21 until July 1.

The following descriptive notes indicate the types of areas preferred by those species for which there are any data.

Pintail - Type A1 areas: 1.5 acres or more in area. Found extensively in flooded fields after rain.

Mallard - Type A1 areas: 1.5 acres or more in area. Found extensively in flooded fields after rain.

Blue-winged teal - Type A1 areas: 1.5 or more acres.

Canvasback - Only one area used, and that for only a few days. A Type A3 area, 3.5 feet deep and 3.1 acres. (The deepest pothole on the study areas.).

Green-winged teal - Type A1 areas of 1.5 acres or more.

Birds of this age showed a definite preference for large, open potholes.

# IX. DISCUSSION

It has been demonstrated in this report that waterfowl broods are able to adjust themselves to varying conditions of habitat such as occurred in 1949 on the Minnedosa area.

## Interspersion of Pothole Types

Owing to their high mobility, waterfowl are well able to make free use of various pothole types. Plate XIX summarizes the use of the various types by the three most critical phases of the breeding cycle and serves to point out the importance of considering the interspersion of the various types. Semipermanent cattail potholes were particularly conspicuous in having the highest percent acreage-use value for diving-duck nests, but very low values for other functions. Permanent sedge-white top potholes, on the other hand, had little importance for nesting but a high rating for breeding pairs and broods. The only type providing a balanced habitat was "Permanent bulrush" which was heavily used by all three phases. We feel certain that temporary waters were undervalued in the study of their use by breeding pairs owing to the late date at which field work was begun.

The data indicate that a region which contains a well-balanced mixture of the various types is highly desirable. To achieve maximum production, this should certainly include enough permanent areas, preferably sedge white-top and bulrush to assure sufficient rearing cover. Without sufficient nesting cover in the form of cattail and bulrush, apparently preferred when found in small, semipermanent potholes, it is doubtful whether many diving-duck broods would be hatched. The same conclusion would apply to suitable upland cover for river-duck nesting. Finally, without sufficiently dispersed breeding territories provided by a large number of semipermanent and temporary potholes, there would be few pairs resident in the region and few nesting attempts.

The above discussion points out the importance of considering this type of habitat as a complex of potholes each having one or more functions in the production of waterfowl but each in turn dependent on its proximity to other potholes which can better serve other functions. To regard each individual pothole as a complete production unit seems illogical if we consider the fact that a pair of canvasback resting on it in the spring may have a nest in an entirely different type some distance removed, and may depend on a third type for brood rearing. None of these potholes should be considered as having produced a canvasback brood, but each was essential to its production even though it might function for only a very short time; rather, the region produced the brood. Thus any consideration of this type of habitat must be based on a unit of land rather than the individual pothole.

In habitat such as the Minnedosa study area, where the potholes are small and closely intermingled, it appears that the square mile is a good unit for consideration. The many small transient areas furnish breeding territories for a large number of pairs while there are numerous potholes suitable for the other phases of the breeding cycle as has been discussed. There was considerable upland cover for river-duck nesting and considerable cattail and bulrush in both permanent and semipermanent potholes for diving-duck nesting. Several areas were used by post-breeding birds and flying young and there were apparently more than enough waters favorable for brood rearing. Finally, all of these factors essential to the reproduction of the species present were contained in an area which was well within the limits of mobility of the species since both adults and young could easily traverse it.

It might be that in other regions where potholes are not so closely intermingled, areas of 1 square mile might not furnish all of the essentials, and larger units should be considered. The ultimate of this trend would be the breeding marsh as described by Hochbaum (1944) in which all necessities are supplied by one unit.

## Implications of Brood Movement and Drying-up of Potholes

Apparently there is continuous movement of broods throughout the season. This suggests that when a pothole near which a nest is located dries up, there is no reason to assume that the brood hatched from it has been lost. Further, if a pothole on which a brood is seen dries up, it can be safely assumed that under normal conditions the brood has managed to reach another pothole which still retains water. Broods can also take advantage of temporarily favorable conditions brought about in the more transient areas by heavy rains such as often occur during the summer.

It is still not known whether broods raised in pothole country can leave a region entirely in order to reach permanent rivers or lakes in times of extreme drought. Some data have been presented which indicate that movement might start early enough in the drying-up period, so that they could travel considerable distance using intervening waters not yet dry for resting and feeding. If that is not true, and they wait until the pothole on which they are located has gone dry, they would probably be lost, since it is the areas last to dry up that are most heavily used for brooding. When these go completely dry, intervening potholes could not be expected to contain water.

In this respect, the system of "kee waters" described by Farrington (1945) might be beneficial in times of drought since broods could reach them even when most natural areas had dried up.

In regions resembling the Minnedosa area, however, the effects would very probably be more detrimental than favorable. It would seem to be poor management to unbalance this desirable interspersion of types capable of producing 50 broods in a normal year in order to produce 10 in times of drought, leaving conditions which might produce only a few more when favorable seasons again occurred.

## Suggestions for Management

The Area Concept -- The intent of the above discussion has been to focus attention on the importance of achieving a balance between the types in an area rather than attempting to make each pothole serve all functions.

Improvement of the Study Area -- We have seen that the study area of $1\frac{1}{2}$ square miles contained more than enough permanent potholes to serve the needs of the broods present as was indicated by the fact that there were some concentrations well above the over-all average which resided together without apparent conflict.

Nesting cover might also be considered superabundant, since there were large expanses of both upland cover and emergent cattail and bulrush which were not utilized even though they were apparently suitable for nesting. However, it should be pointed out, this wide distribution of over-water nesting cover may be important in attracting such species as canvasbacks and redhead for nesting.

The low percent of occupancy of territorial sites during the spring suggests that these also were not fully utilized, but it is felt that there is not enough known concerning the spatial requirements of breeding pairs to justify this assumption.

The one step in improvement of the habitat which is apparent from this study is that of increasing the number of available breeding territories. Plate XIX indicates

that the major use of permanent cattail potholes was as nesting cover which is apparently not a critical item, while they were of purely secondary value for both territorial sites and brood rearing, presumably owing to their dense cattail margins. It appears that protection from grazing which would allow sedge-whitetop margins to develop might improve their qualities as territorial waters. This would also be applicable in regions where potholes suitable for brood rearing were scarce.

A few additional small temporary areas could be created by placing small dams across waterways, but this would be at the expense of potholes already existing at the ends of these waterways.

The development of sedge-whitetop cover in denuded areas by complete or partial protection from grazing might be benficial. The application of this measure should be guided by further study of the requirements of the breeding population and of the ecology of cattail and bulrush.

The present high productivity of the study area is undoubtedly due to its climate, physiography, and chance application of the management practices discussed. Climate and glacial action produced an abundance of potholes of varying size, some of considerable permanence, lying in an area of relatively good soil, while the diversified land use brought about by small farming units has undoubtedly created the close interspersion of various cover types discussed in the introductory section. These factors combined to produce a nearly ideal balance of types. Farming operations have not become so intensified and grazing is not generally so severe in this area as to cause a serious general reduction in upland nesting cover.

Inasmuch as pressure on breeding habitat is increasing with the increase in hunting, while the available areas are diminishing with the expansion of agriculture, it seems desirable that programs for management be set up as rapidly as possible, even though we may not know the final answers to many questions. It is felt that trained observers, bearing the above concepts in mind and using aerial photographs.

## X. SUMMARY

1. The potholes on the study area have been classified according to permanency and vegetation in order that their use by waterfowl might be correlated with described types.

2. The factors influencing pothole types have been discussed and a postulated plant succession in the potholes of the region has been outlined.

3. By means of marking the young, it was found that some broods moved overland considerable distances and made use of more than one pothole.

4. By analysis of the periods broods resided in potholes, it was possible to determine the relative mobility of species. Pintail broods were the most mobile, followed in order by canvasback, mallard, redhead, blue-winged teal, and baldpate, while ruddy-duck broods were the least mobile. No motherless broods of any species were known to travel overland.

5. By analysis of the movements of the brood population as a whole, it was determined that movements of canvasback, redhead, mallard, and pintail extended beyond the limits of the study area thus influencing the measurement of their populations.

6. Owing to the mobility of broods, allowing them to select suitable areas, it was possible to gain data on their preferences. It was found that their first preference was large open areas with sedge-whitetop margins, while similar areas with bulrush cover were a close second.

7. It was found that movement was stimulated both by high or rising water levels and by rapidly falling water levels.

8. Depth was found to be an important factor influencing the selection of potholes. During periods of low water, potholes more than 2 feet deep were definitely preferred to shallower areas.

9. The abundance of potholes was found to have an effect on movement, and the most movement took place where potholes were closely spaced.

10. Food appeared to be an unimportant factor in the selection of potholes.

11. The presence of other broods or other waterfowl species did not appear to influence the use of areas by duck broods.

12. Human intrusion was found to influence brood movement in some cases, but it often had little effect and some broods could not be driven from their potholes.

13. It was found that as broods became older their mobility increased.

14. Brood mortality on the study area was lower than expected. The canvasback and mallard, which made up nearly half of the obervations, suffered no known losses of young. The loss during an average period of 25 days was roughly 10 per cent. Most of the birds lost were Class I.

15. Diving-duck broods were found to disperse earlier than broods of river ducks.

16. Young ducks in the wild appeared to require less time to reach flying age than the same species raised in captivity.

17. The study area was found to support 88 breeding pairs per square mile which produced 50 broods per square mile (a success ratio of 0.56 broods per pair).

18. Breeding-pair use was found to be greatly influenced by pothole size. River-duck pairs showed greatest per acre use of areas 0.0 to 0.5 acres in size. Diving ducks preferred areas of 2 to 3 acres. Cover did not seem to be as important to these birds as to broods.

19. Diving ducks preferred small cattail and hardstem-bulrush potholes for nesting. The heaviest per acre use occurred in semipermanent cattail areas. The locations of neither diving-duck nor river-duck nests appeared to depend on the presence of territorial or brood-rearing areas in the immediate vicinity.

20. On attainment of flight, the young preferred large open potholes. River ducks made considerable use of flooded fields while canvasback used only the deepest pothole on the study area.

21. It was concluded that management of waterfowl breeding habitat in regions of small water areas is dependent upon the maintenance of a proper interspersion of pothole types, each to serve its own function. We should therefore be concerned with management of the pothole habitat as a whole rather than with the manipulation of the characteristics of individual areas.

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Crissey from p 133

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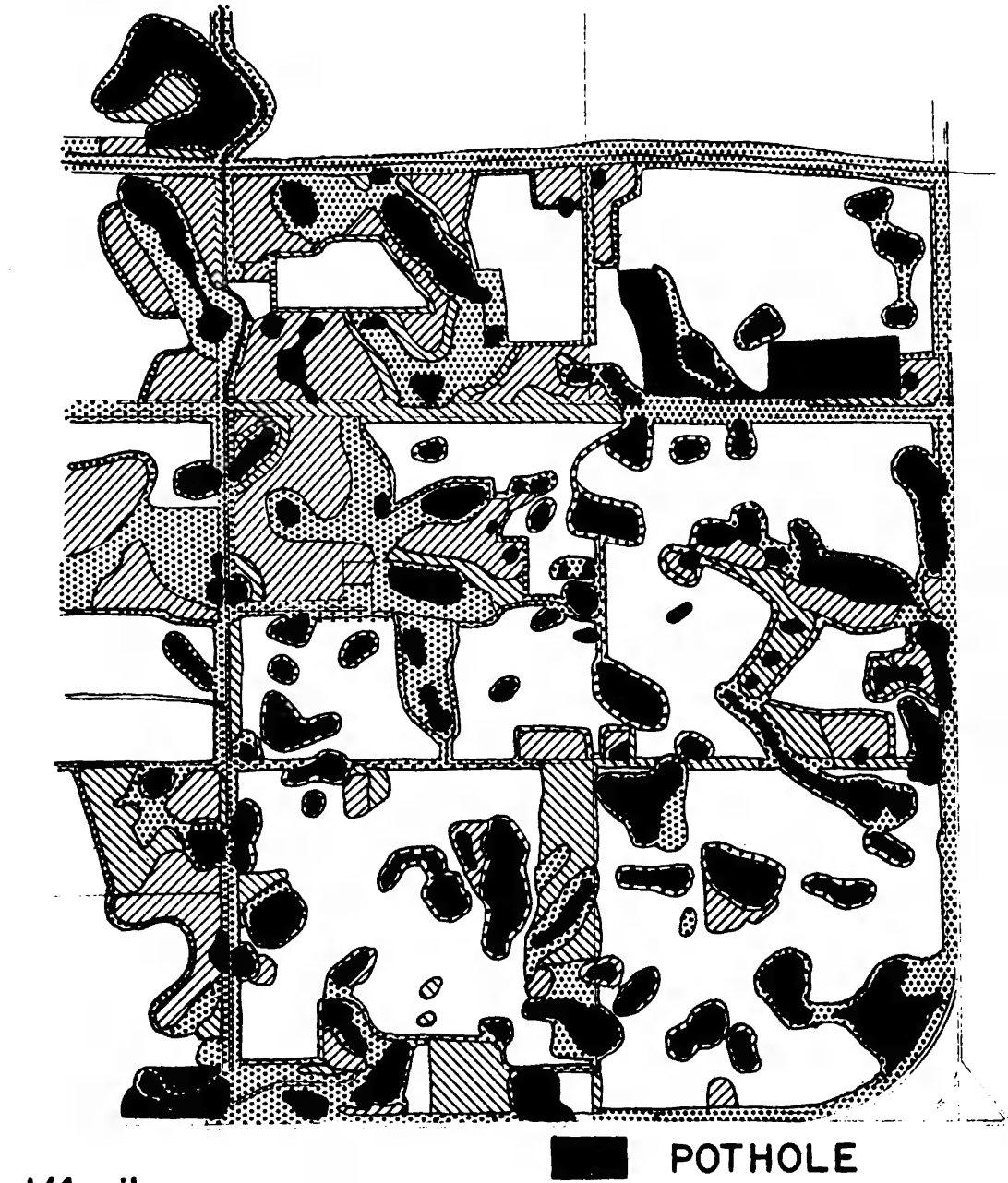
# PLATE II

## UPLAND COVER ON STUDY AREA



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# PLATE III
# POTHOLE TYPES FOUND ON STUDY AREA
# (GROUP C AREAS NOT INCLUDED)

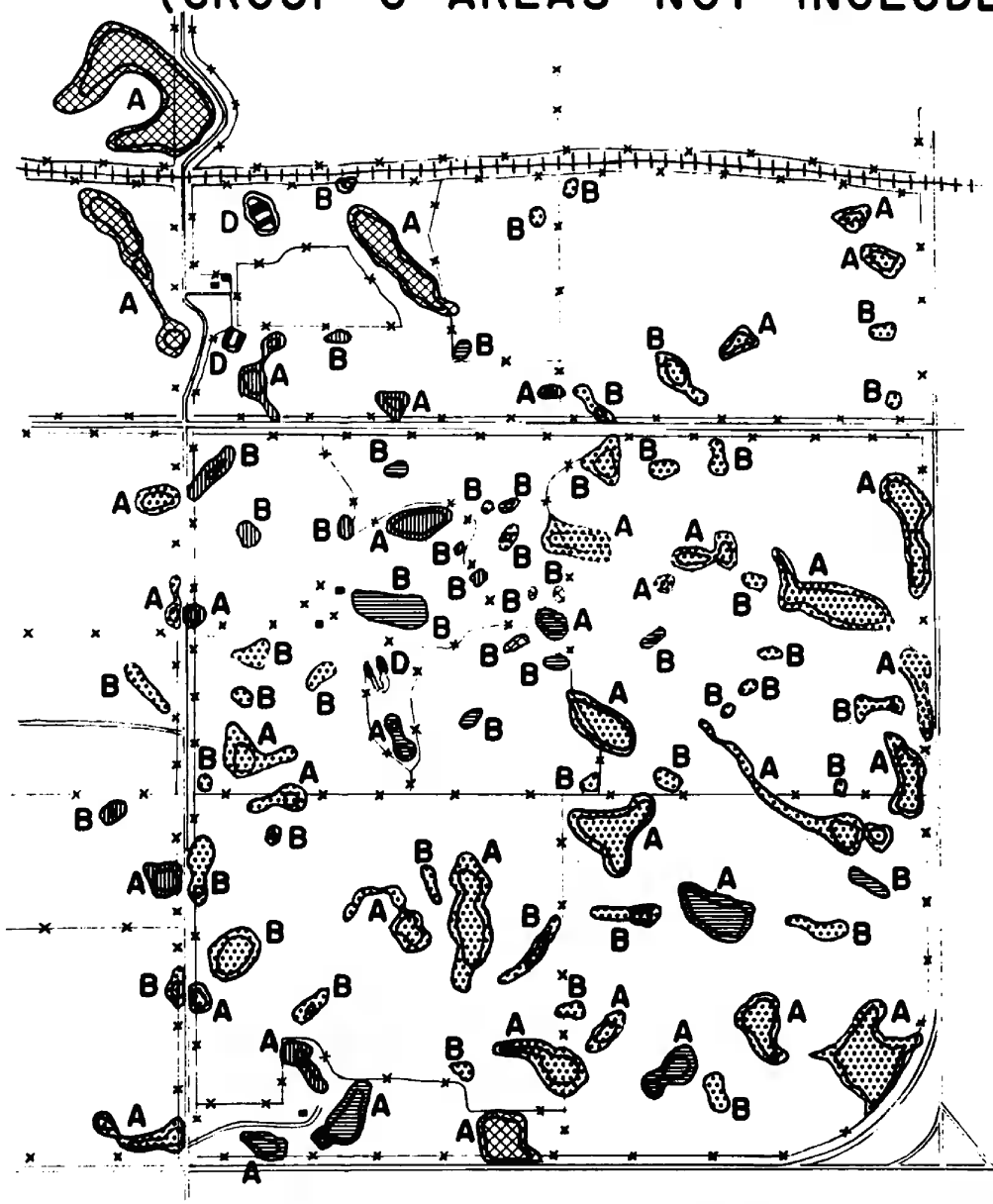

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PLATE IV

# COVER MAP OF POTHOLE NO. 40

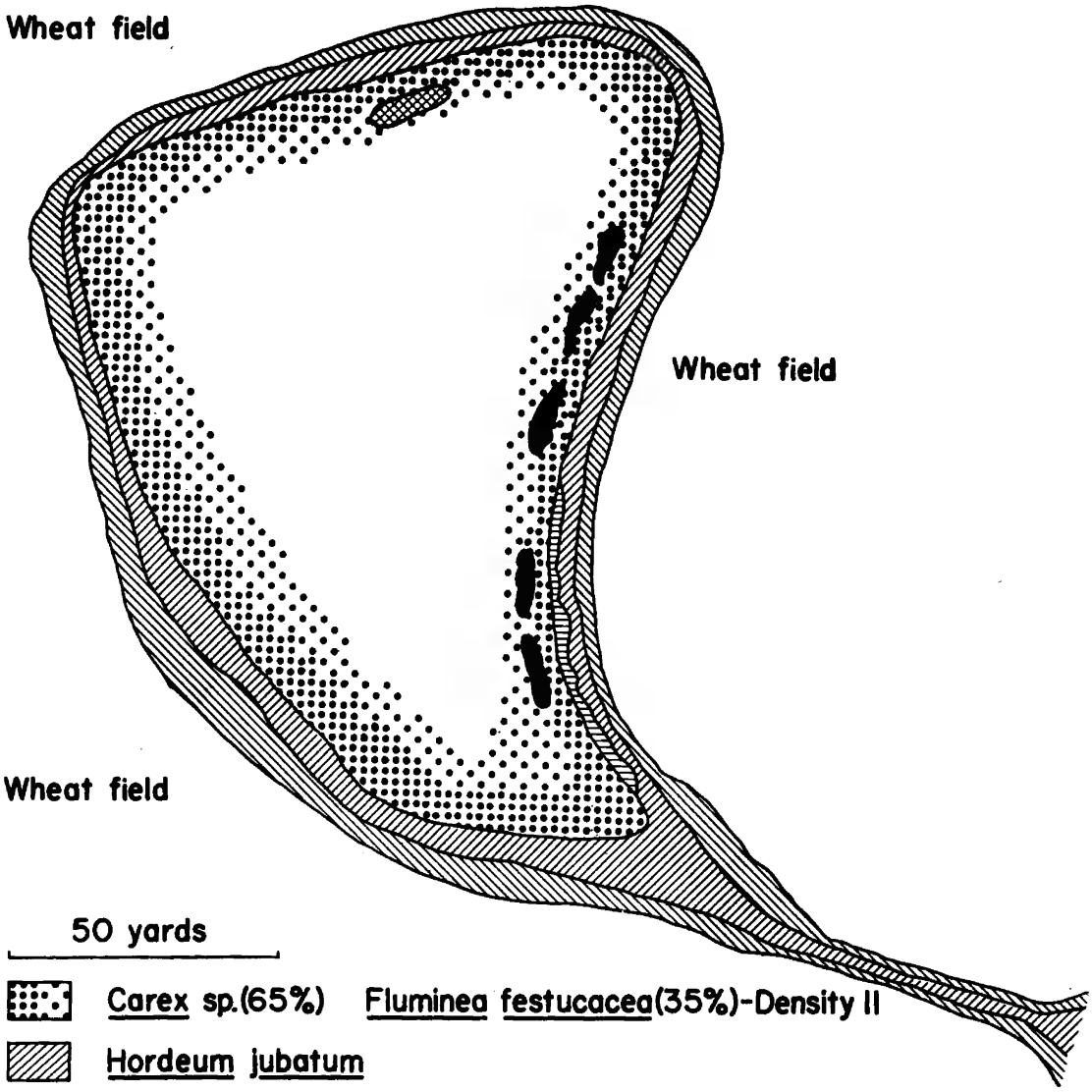

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PLATE V

# COVER MAP OF POTHOLE NO. 14

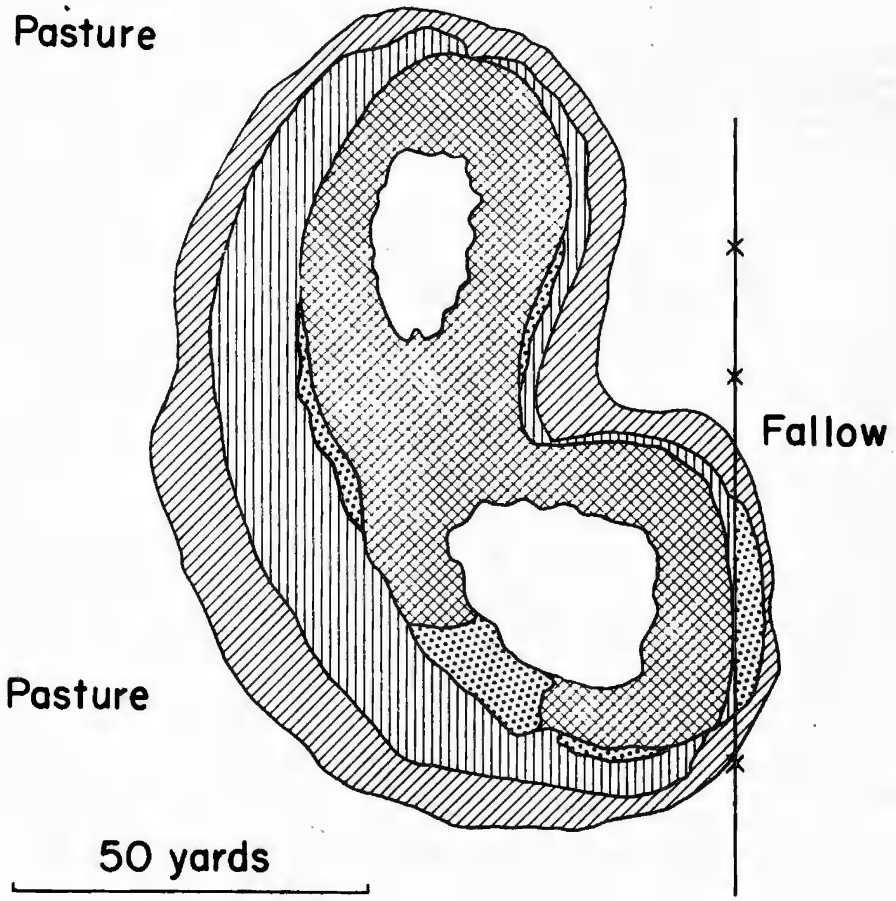

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PLATE VI

# COVER MAP OF POTHOLE NO. 2

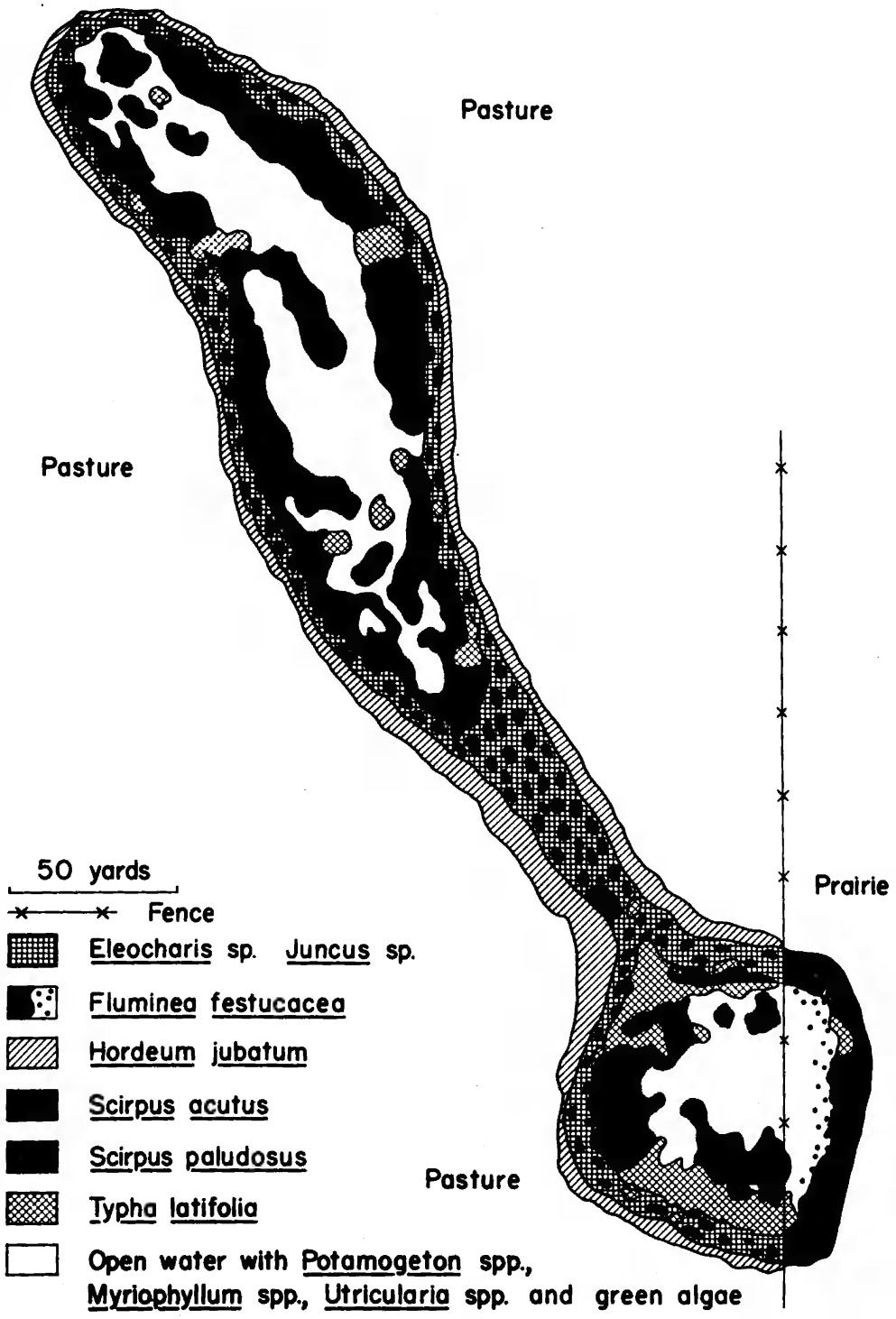

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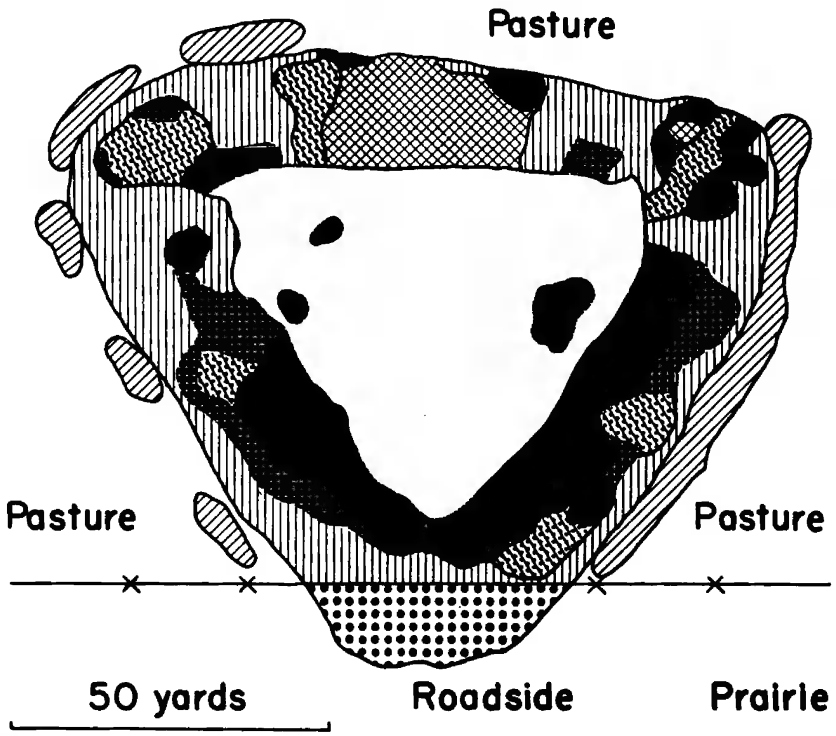
PLATE VII

# COVER MAP OF POTHOLE NO. 4



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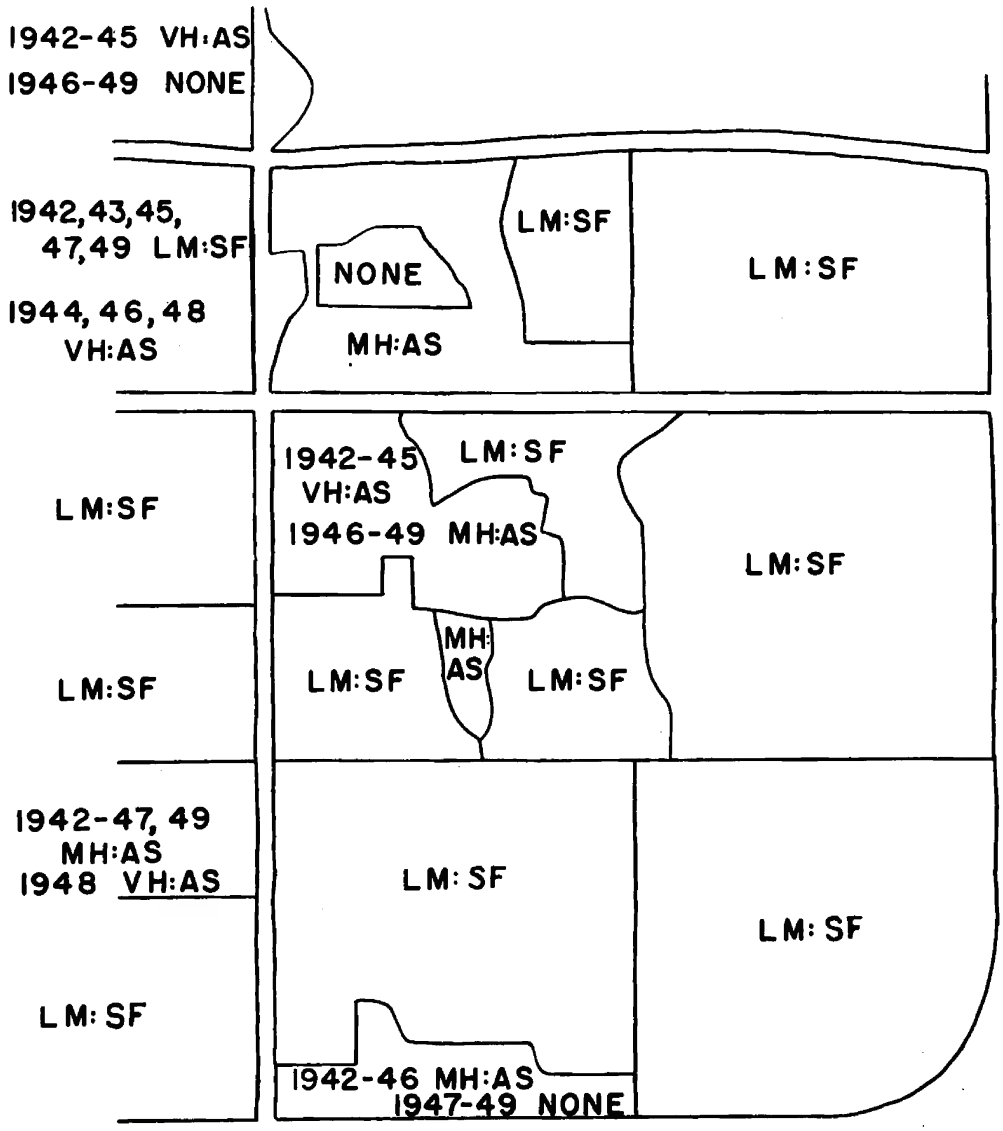
# PLATE VIII

# GRAZING ON LAND USE UNITS OF STUDY AREA : 1942 - 1949




MH:AS GRAZING MODERATE TO HEAVY, ALL SEASON

VH:AS GRAZING VERY HEAVY, ALL SEASON

LM:SF GRAZING LIGHT TO MODERATE, SPRING AND FALL

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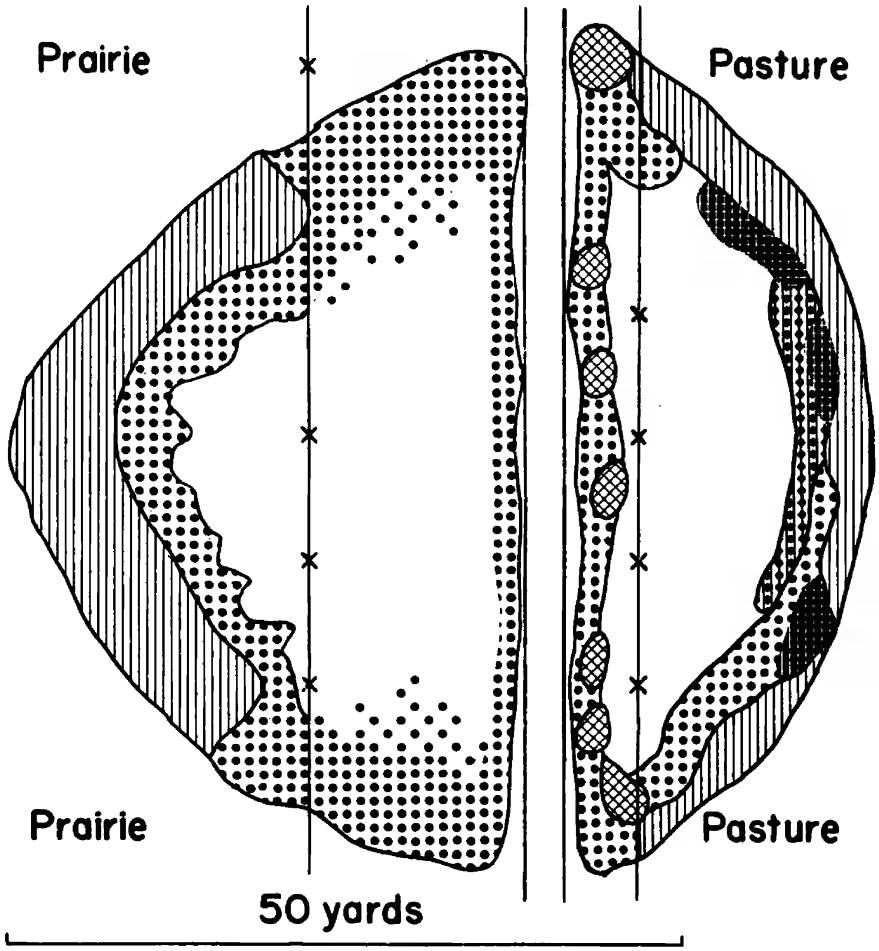
# PLATE IX

## COVER MAP OF POTHOLES II AND 12



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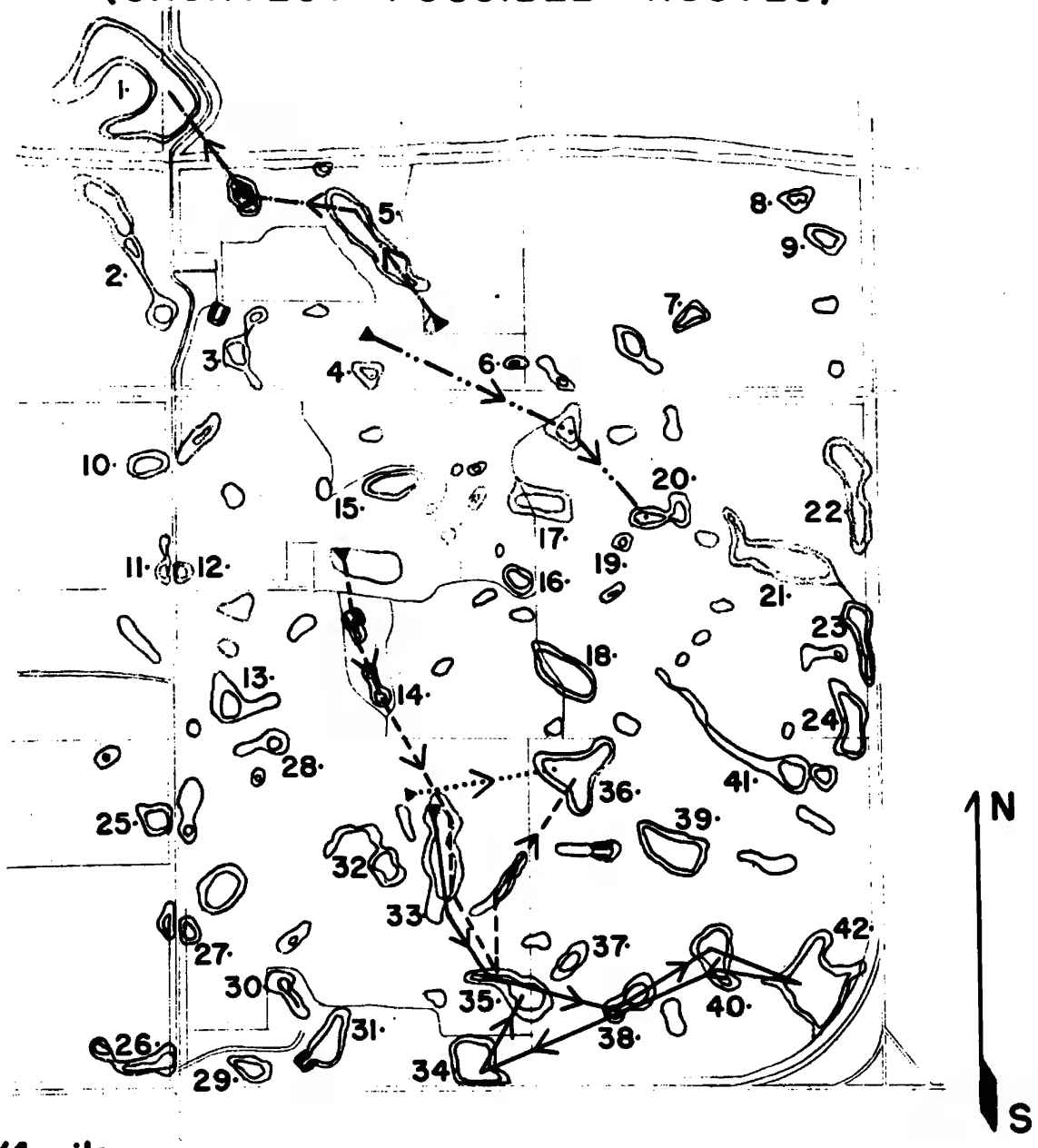
# PLATE X
# MOVEMENTS MARKED BROODS
# (SHORTEST POSSIBLE ROUTES)



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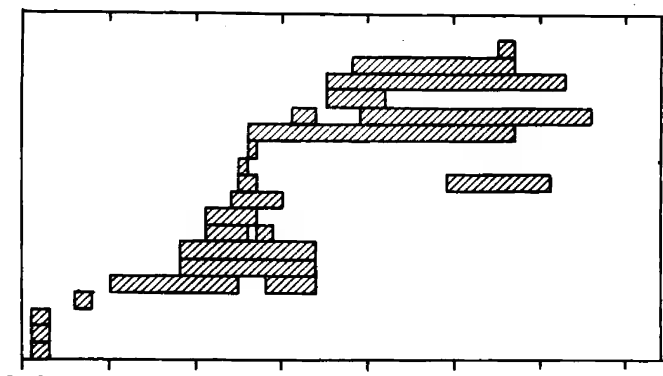
# PLATE XI

## BROODS OCCUPYING POTHOLE NO. 33

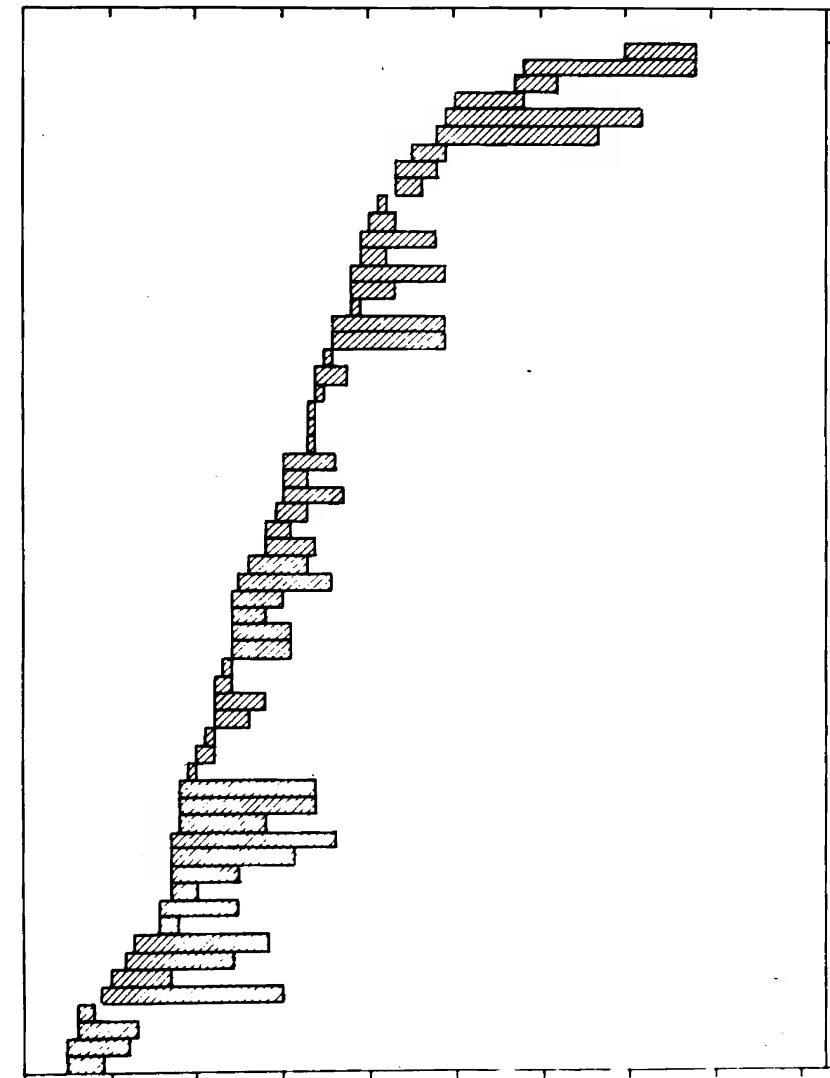


| SPECIES | NO. OF YOUNG | AGE CLASS * |
|---|---|---|
| BLUE-WINGED TEAL | — | — |
| BALDPATE | 2 | I |
| REDHEAD | 8 | I |
| BLUE-WINGED TEAL | 6 | II |
| BALDPATE | 6 | I |
| GREEN-WINGED TEAL | 8 | II |
| PINTAIL | — | II |
| GADWALL | 10 | I |
| PINTAIL | 2 | I |
| CANVAS-BACK | 6 | II |
| BLUE-WINGED TEAL | 11 | I |
| PINTAIL | 4 | III |
| CANVAS-BACK | 1 | I |
| CANVAS-BACK | 3 | I |
| MALLARD | 1 | II |
| CANVAS-BACK | 7 | I |
| MALLARD | 9 | I |
| PINTAIL | 9 | II |
| UNIDENTIFIED | — | — |

6/12 6/22 7/2 7/12 7/22 8/1 8/11 8/21 DATE

*AGE WHEN FIRST OBSERVED

## CANVAS-BACK RESIDENCE CHART



| POTHOLE NO. | AGE CLASS |
|---|---|
| 41 | III |
| 1 | II |
| 34 | II |
| 34 | III |
| 35 | II |
| 40 | II |
| 37 | II |
| 42 | II |
| 1 | III |
| 10 | I |
| 24 | III |
| 22 | III |
| 23 | II |
| 35 | II |
| 40 | I |
| 34 | II |
| 40 | I |
| 40 | III |
| 22 | III |
| 35 | I |
| 23 | III |
| 22 | III |
| 24 | I |
| 24 | II |
| 1 | II |
| 21 | III |
| 21 | II |
| 41 | II |
| 22 | I |
| 22 | I |
| WEST OF 39 | II |
| 39 | III |
| 33 | II |
| 23 | I |
| 34 | II |
| 22 | II |
| 31 | II |
| 28 | I |
| 9 | II |
| 8 | I |
| 29 | II |
| 13 | I |
| 22 | I |
| 33 | I |
| 33 | I |
| 21 | II |
| 1 | I |
| 1 | I |
| 1 | I |
| 24 | I |
| 40 | I |
| 1 | I |
| 1 | I |
| 5 | I |
| 39 | I |
| 36 | II |
| 33 | I |
| 5 | I |
| 37 | I |
| 36 | I |

6/12 6/22 7/2 7/12 7/22 8/1 8/11 8/21 8/31 DATE

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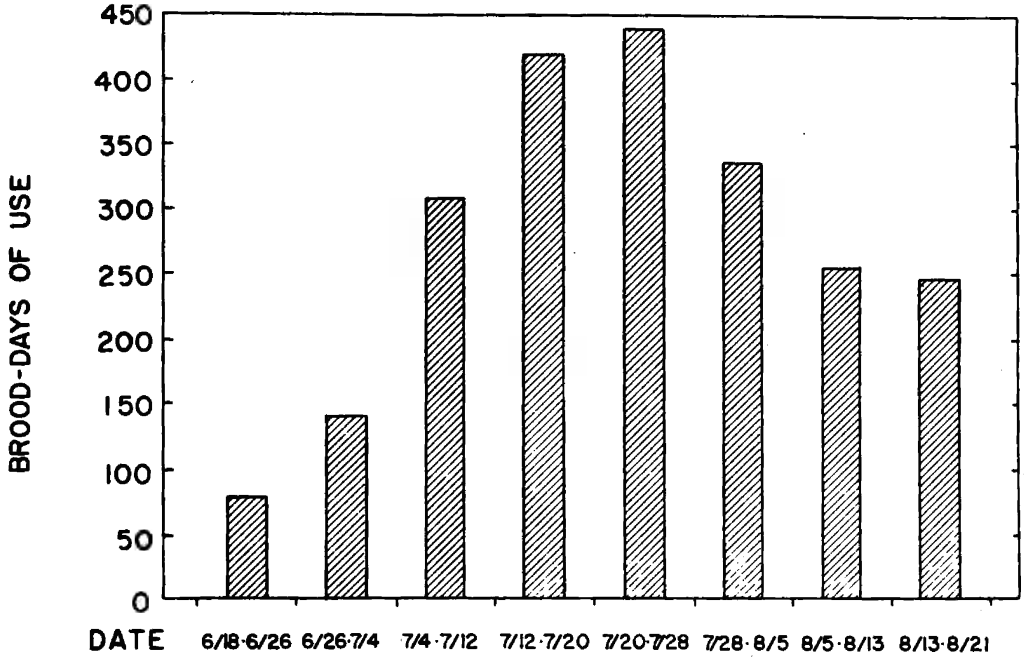
PLATE XII

SEASONAL FLUCTUATIONS IN USE OF THE STUDY AREA BY BROODS




SPECIES COMPOSITION OF BROOD POPULATION (TOTAL BROOD-DAYS)

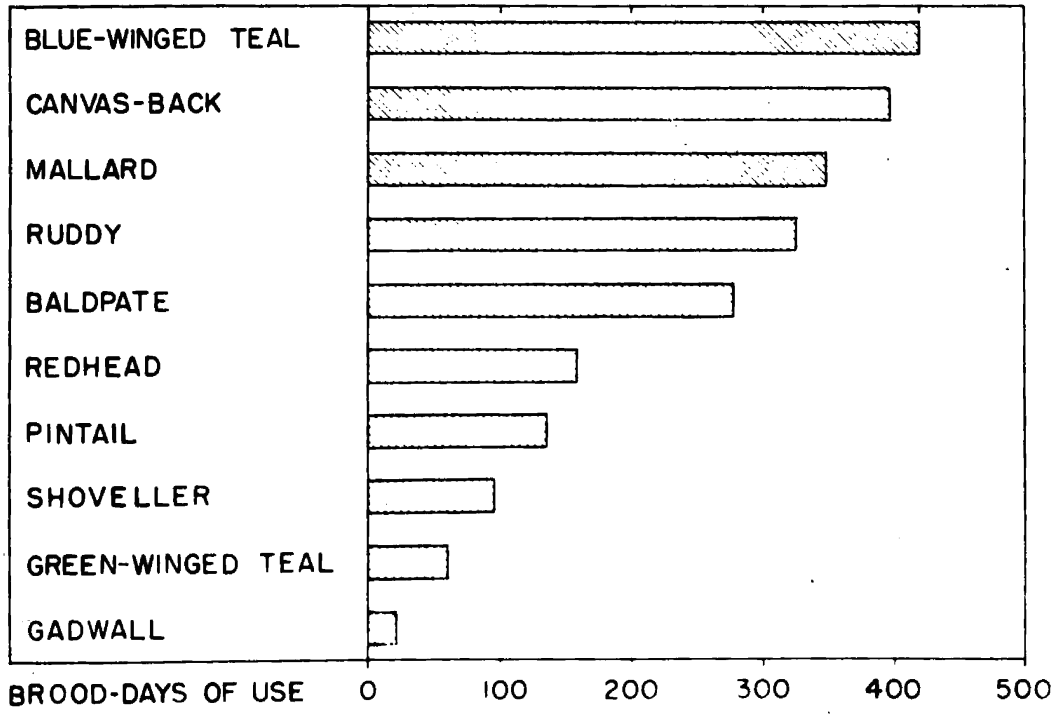


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PLATE XIII

# SEASONAL FLUCTUATIONS IN BROOD POPULATIONS BY AGE CLASSES

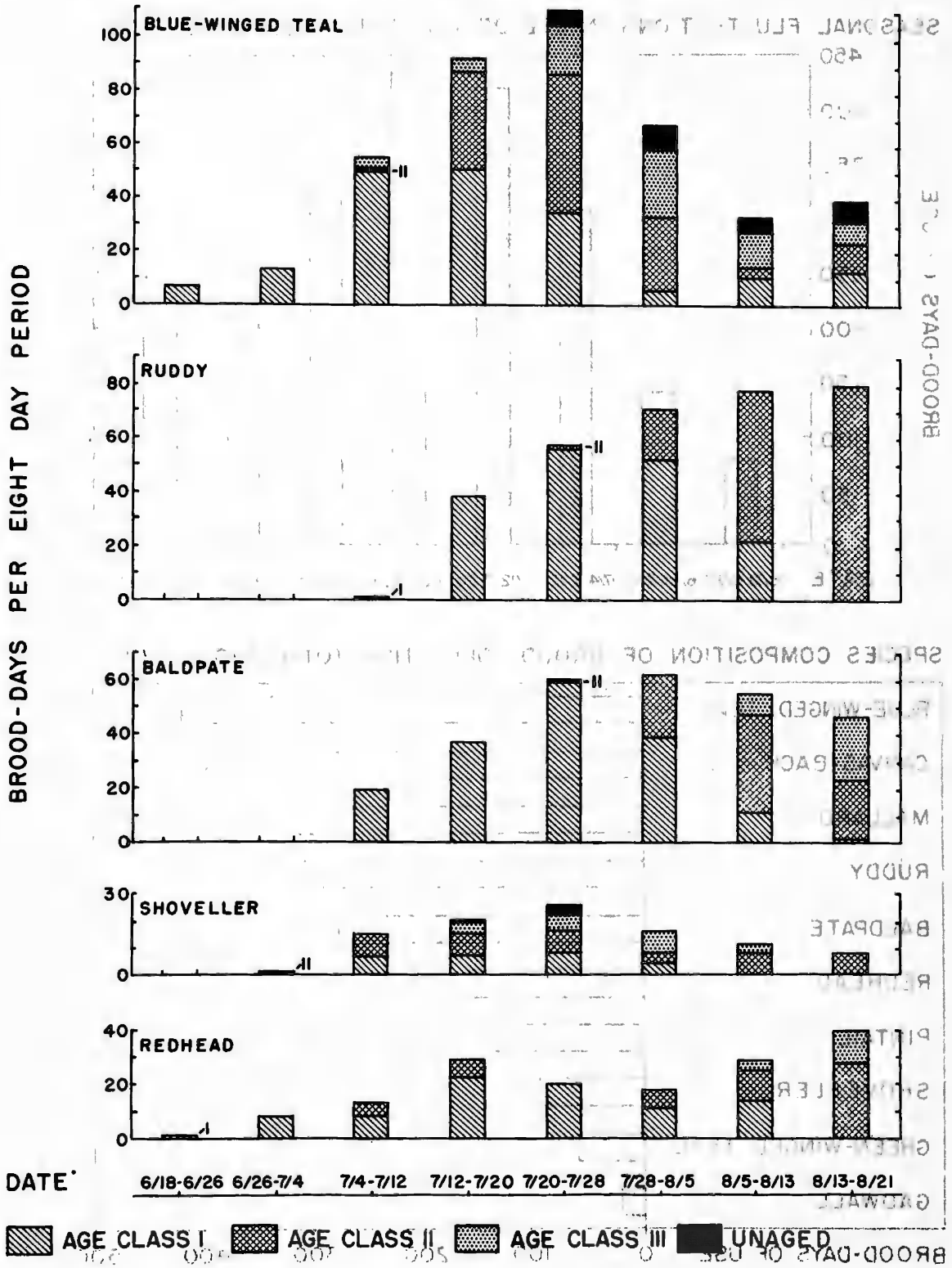

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PLATE XIV

# SEASONAL FLUCTUATION IN BROOD POPULATIONS BY AGE CLASSES

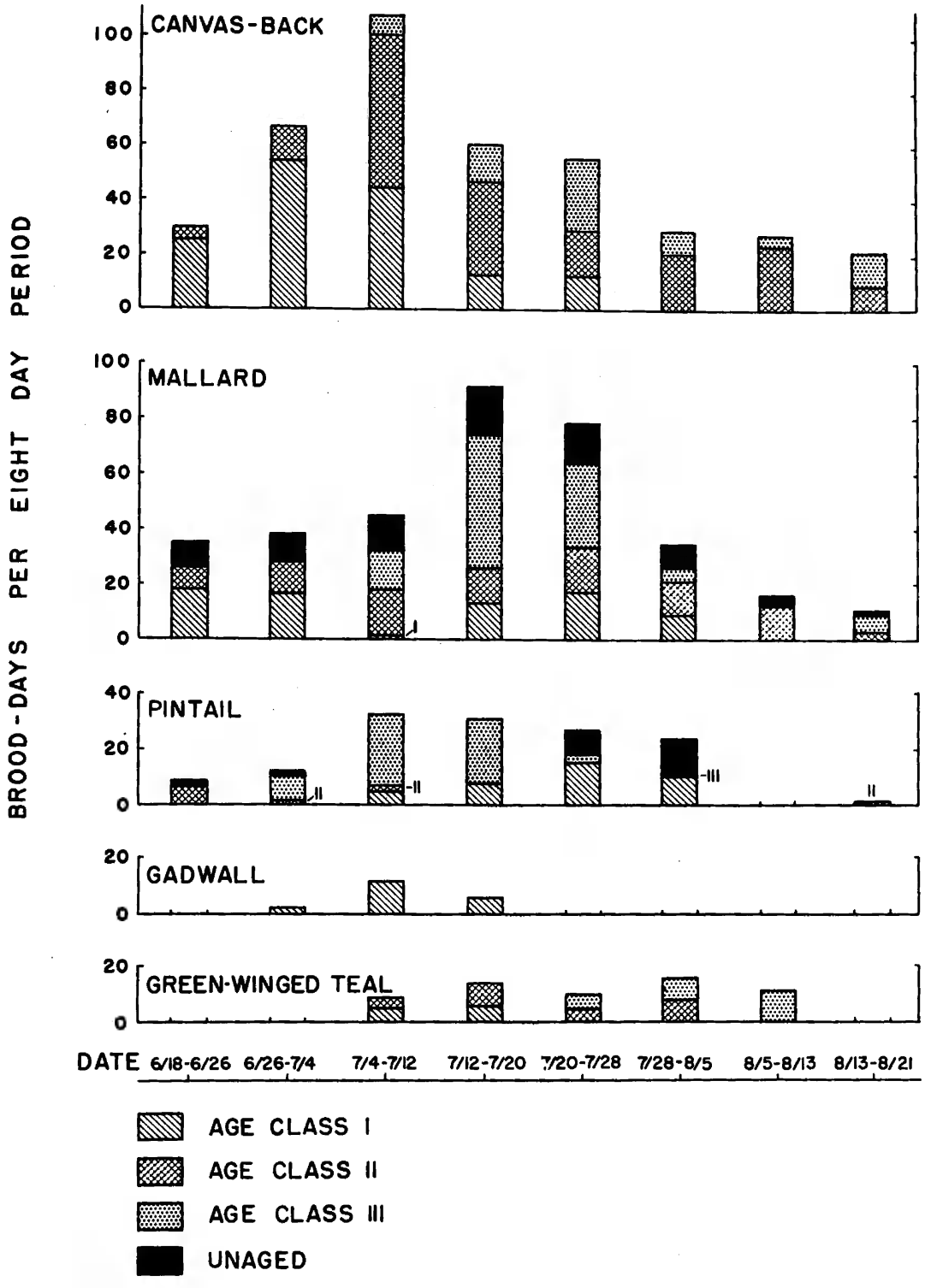

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PLATE XV

# FLUCTUATIONS IN MOBILITY OF CANVASBACK BROODS

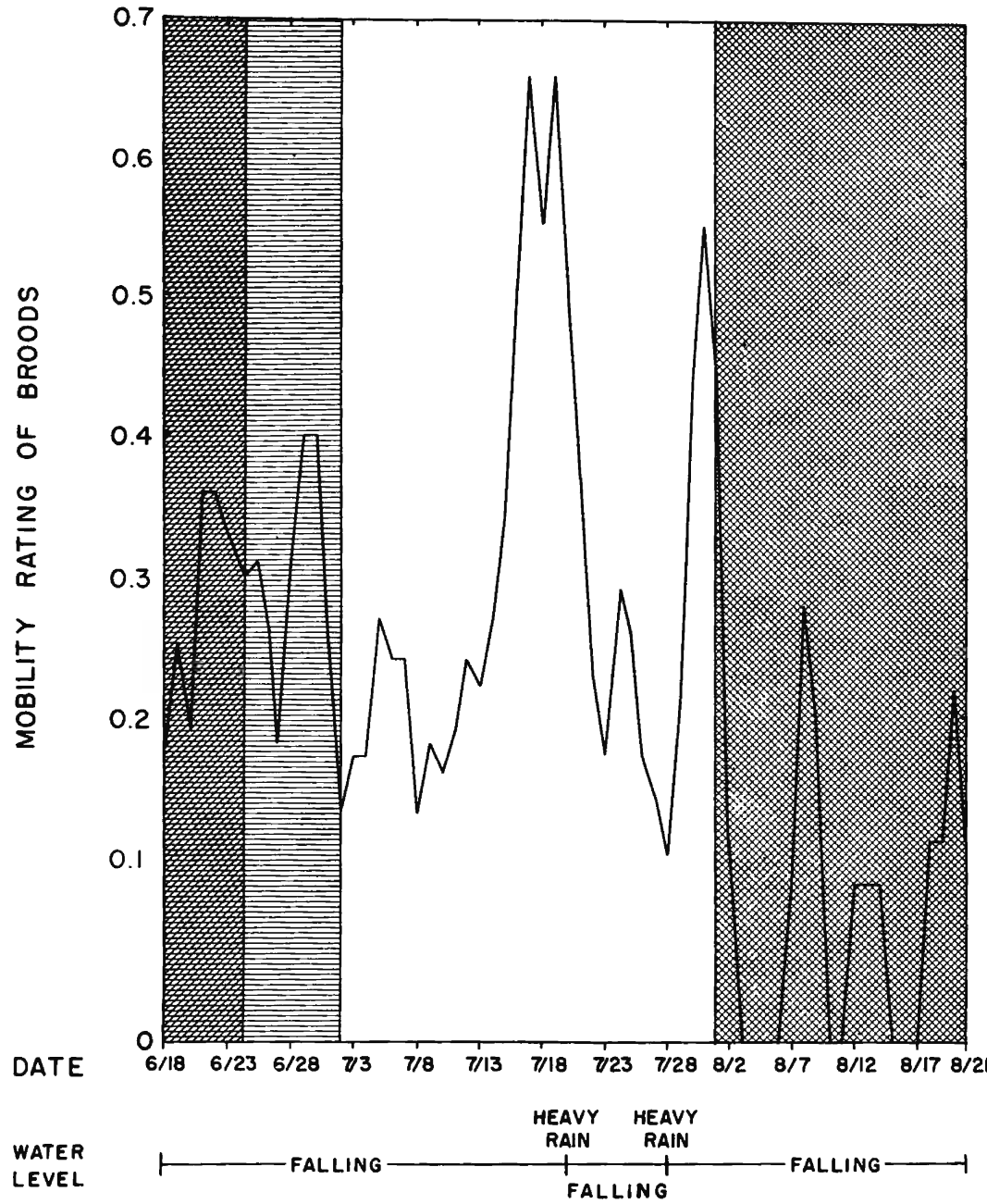

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PLATE XVI

# THE USE OF POTHOLES IN TWO DEPTH CLASSES BY TWO SPECIES OF RIVER DUCKS AND TWO SPECIES OF DIVING DUCKS

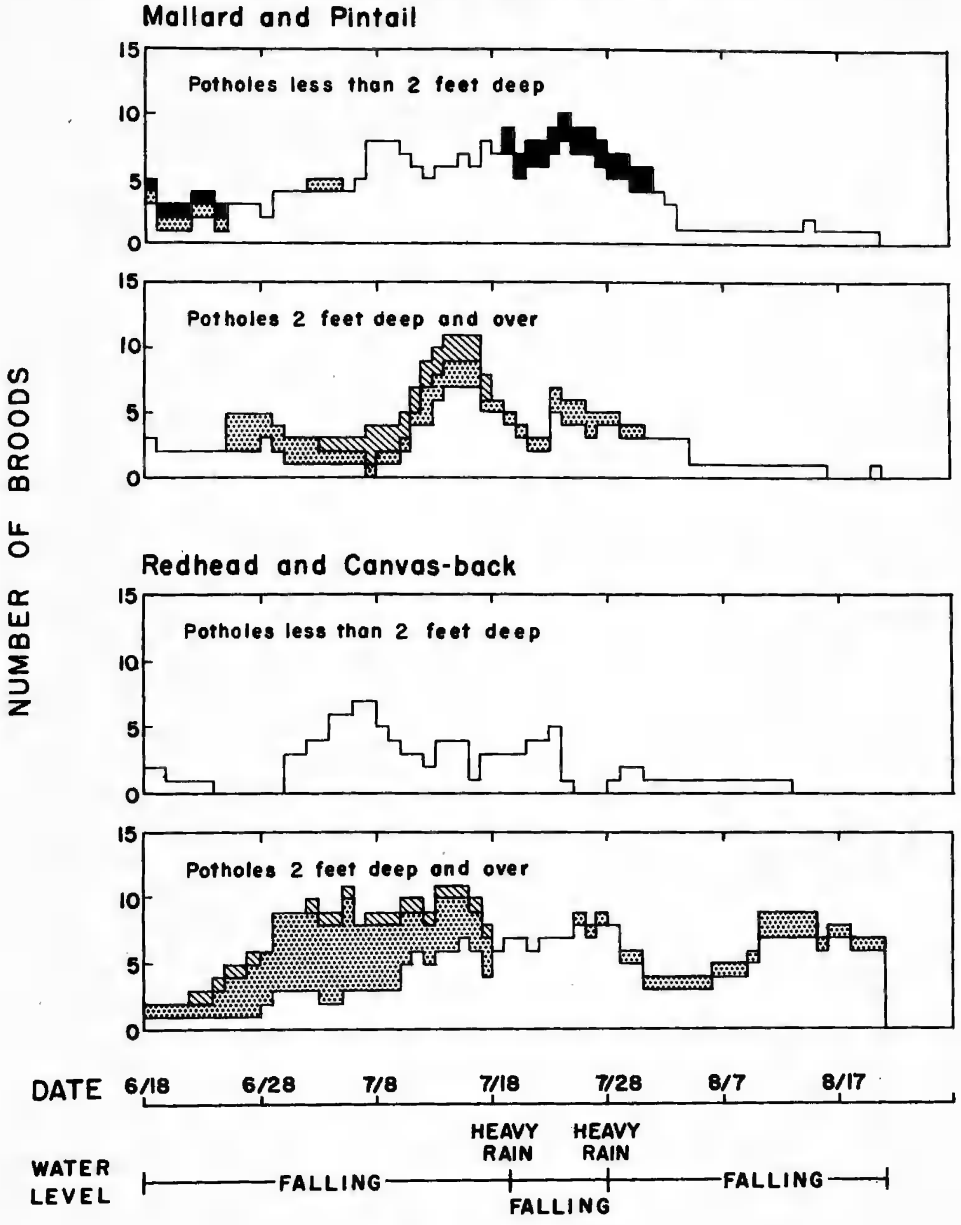

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PLATE XVII

DAILY CHANGES IN BROOD NUMBERS
IN POTHOLE NO. 33

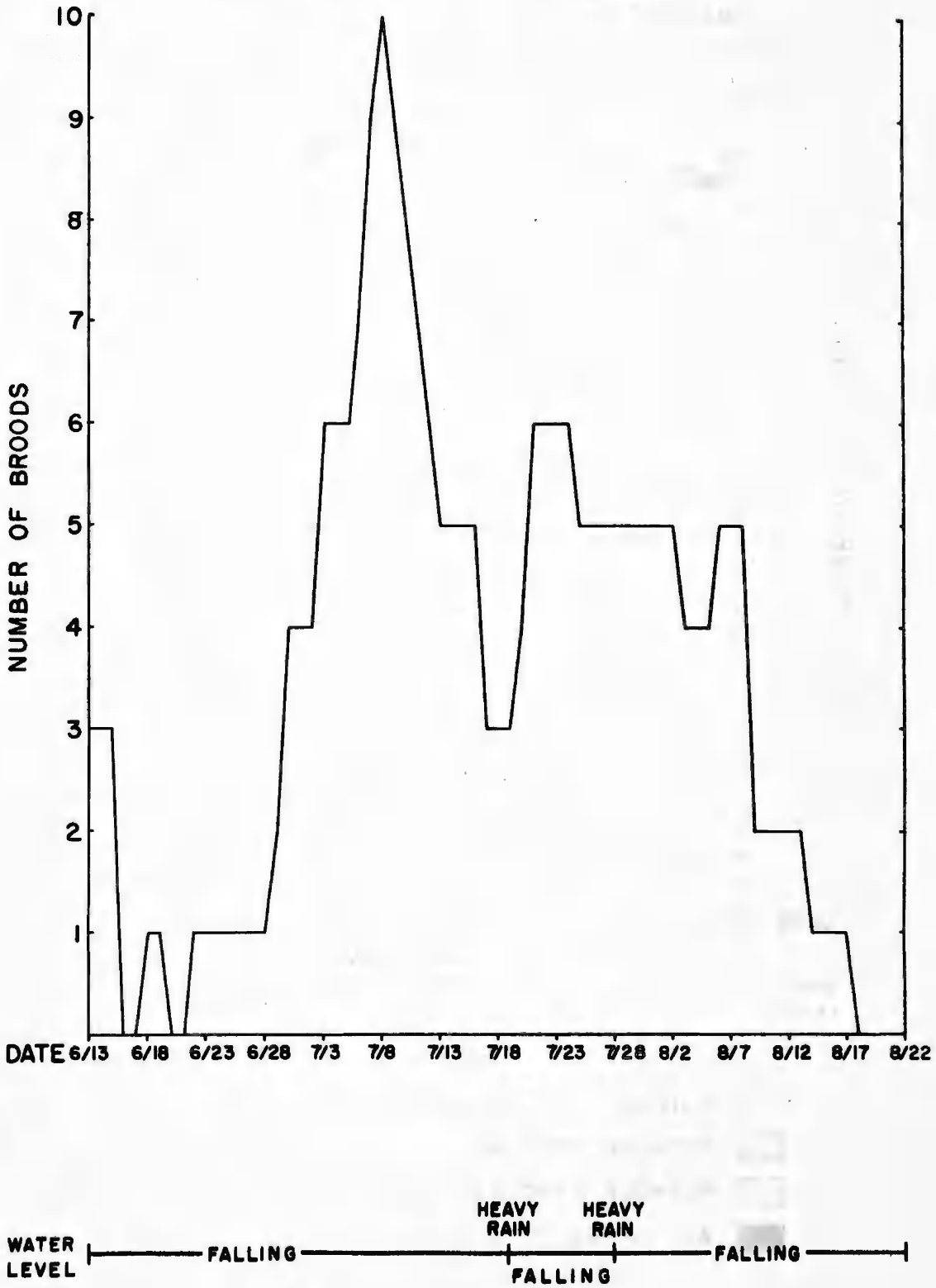

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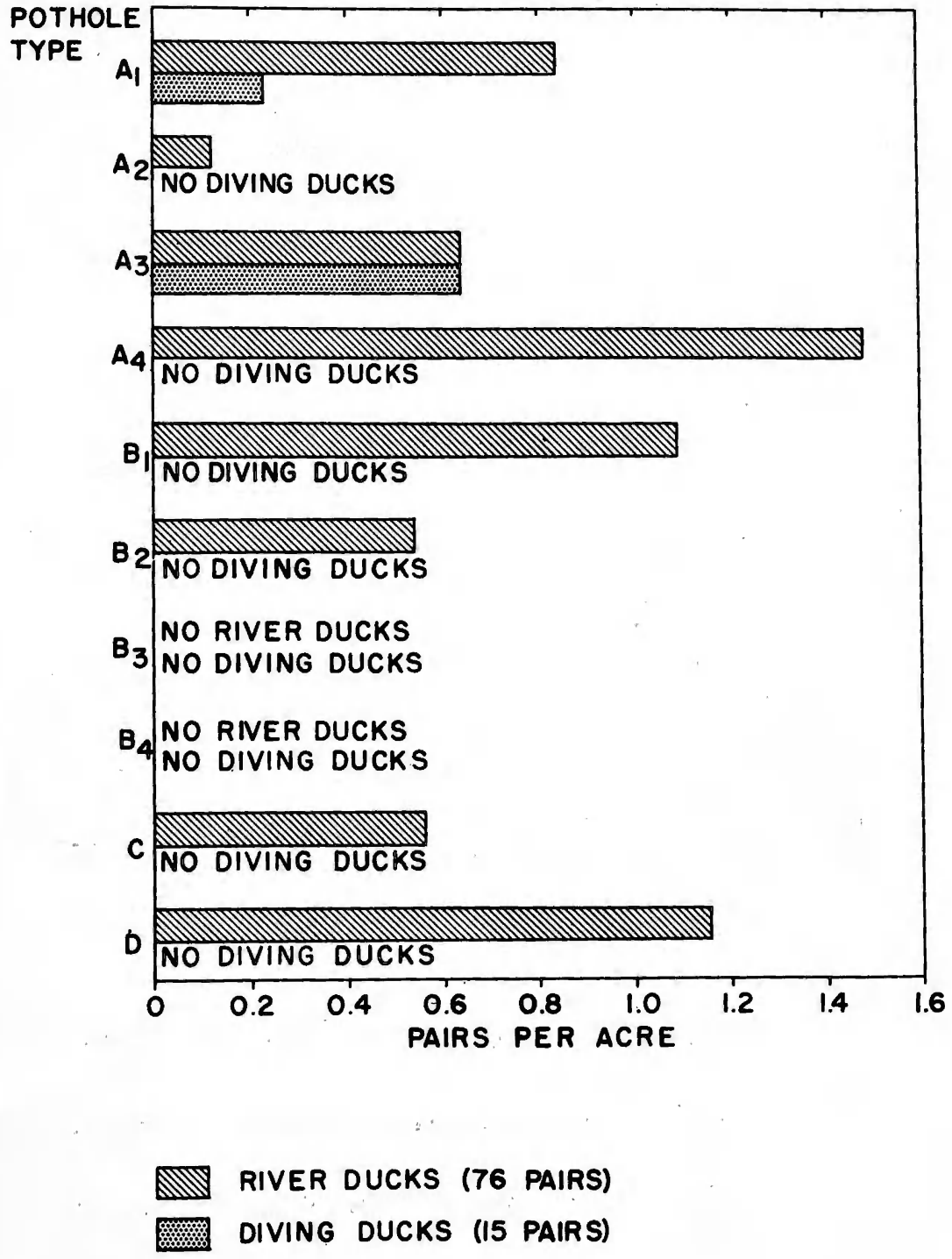
PLATE XVIII

# THE USE PER ACRE OF ALL POTHOLES TYPES BY BREEDING PAIRS



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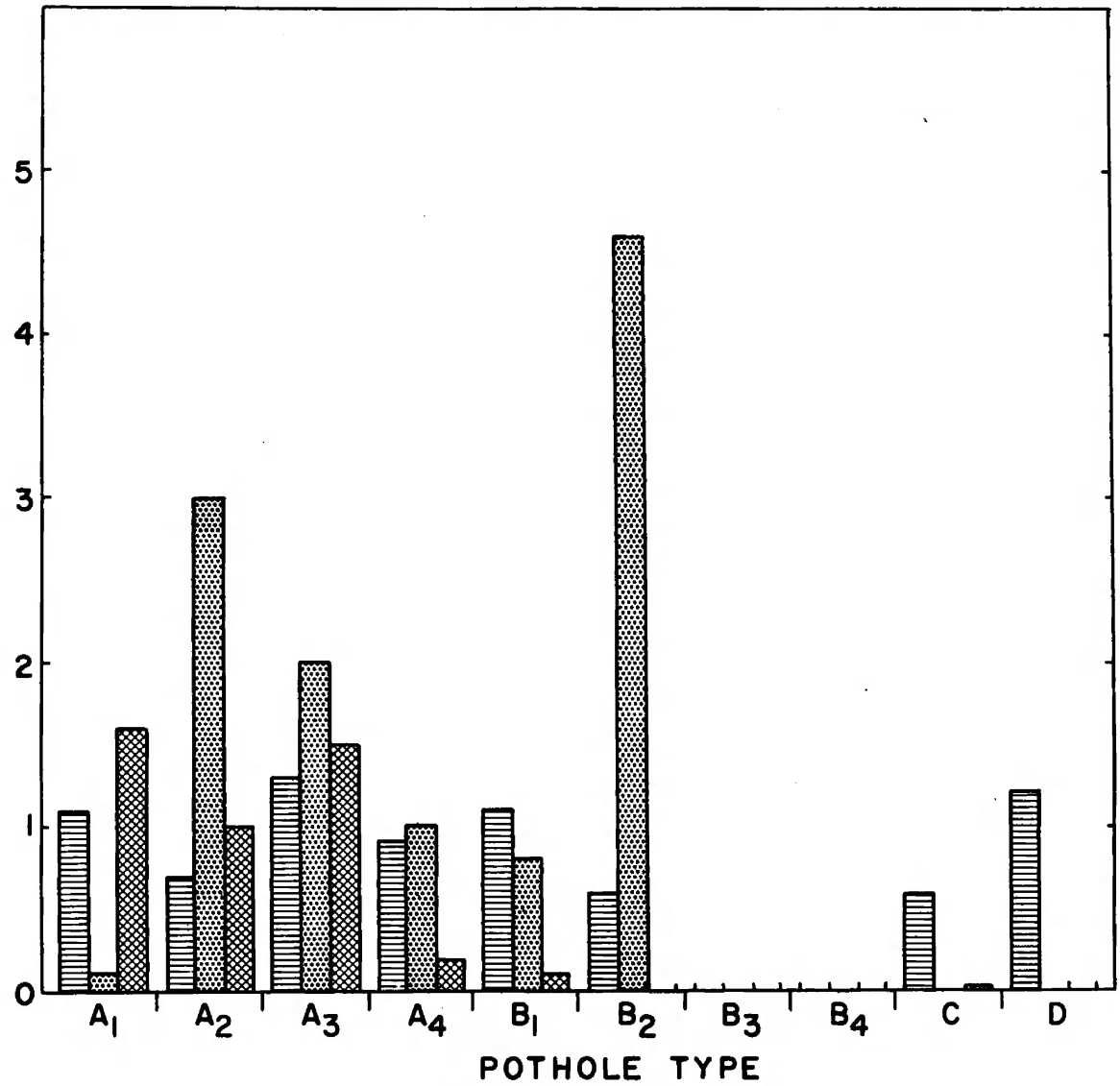
# PLATE XIX

## PERCENT ACREAGE-USE VALUE OF 10 POTHOLE TYPES FOR THREE PHASES OF THE WATERFOWL BREEDING CYCLE; MINNEDOSA, MAN., 1949 (127 POTHOLES)




Percent Acreage-Use Value for Breeding Pairs

Percent Acreage-Use Value for Diving Duck Nests

Percent Acreage-Use Value for Brood Rearing

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